University of Alberta

Orthodontic Treatment Duration in Class II Patients

by

Kurt S. Popowich ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science in Orthodontics

Department of Dentistry

Edmonton, Alberta

Spring 2003

National Library of Canada
Acquisitions and Bibliographic Services
395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque nationale du Canada
Acquisitions et services bibliographiques
395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence

Our file Notre référence

The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

L'auteur conserve la propriété du droit d'auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

0-612-82333-4

Canada

University of Alberta

Library Release Form

Name of Author: Kurt S. Popowich

Title of Thesis: **Orthodontic Treatment Duration in Class II Patients**

Degree: Master of Science

Year this Degree Granted: 2003

Permission is hereby granted to the University of Alberta Library to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

The author reserves all other publication and other rights in association with the copyright in the thesis, and except as herein before provided, neither the thesis nor any substantial portion thereof may be printed or otherwise reproduced in any material form whatever without the writer' s written permission.

Kurt S. Popowich
3 Desevigny Place
St. Albert, AB
T8N 6R8

Date: Mar. 19, 2003

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Orthodontic Treatment Duration in Class II Patients** by Kurt S. Popowich, in partial fulfillment of the requirements for the degree of Master of Science in Orthodontics.

Paul W. Major, Supervisor

Kenneth E. Glover

Brian Nebbe

Giseon Heo

Date: Mar. 18, 2003

Sharon Warren

Dedication

To my wife Deana who provided her endless support to me over the past two and a half years. Thank you for your love, patience and encouragement, which was instrumental in achieving my career ambitions.

Abstract

The purpose of this investigation was to utilize a cohort comparison group (class I non-extraction) from 3 different orthodontic offices, to assess the relative treatment time difference (months / appointments) between class II (extraction and non-extraction) and class I patients. The estimated treatment length was compared with the actual treatment length to determine the accuracy of orthodontists in predicting treatment duration, as well, we attempted to identify any clinical factors predictive of treatment length for class II malocclusions. A total of 237 patients were included in this study. The results of this investigation indicated that among the 3 orthodontic offices, no standard treatment time difference (months or appointments) could be determined between the class I and class II groups. The treatment length in 4 of the 9 observational groups was significantly underestimated, and various clinical factors (patient, model, cephalometric and treatment) were found to be significantly associated with treatment duration.

Acknowledgement

I would like to thank my supervisor, Dr. Paul Major for his direction and wisdom and would also like to thank my committee members, Dr. Brian Nebbe, Dr. Giseon Heo, Dr. Ken Glover and Dr. Sharon Warren for their insight and feedback throughout this project.

I would like to thank the orthodontists who provided me with access to their patient records for this research.

I would like to thank all of the clinical instructors for their patience and friendship, as they provided me with an excellent orthodontic education.

I would like to thank Brigitte, Gail, Susan, Wendy, Jacalyn, Lori, Pat, and Cindy for all their help over the past two and half years. They made the orthodontic clinic a great place to work.

I would like to thank my fellow residents, especially Darcy and Farah, for their friendship and support throughout my program.

Table of Contents

Chapter One – Introduction and Literature Review		1
1.1	Introduction	2
1.2	Effect of Different Variables on Orthodontic Treatment Duration	2
1.3	Effect of Extractions on Orthodontic Treatment Duration	5
1.4	Correlation of Malocclusion Severity to Treatment Duration	6
1.5	Treatment Duration Associated with Specific Malocclusion Types	7
1.6	Patient Age (Adolescent or Adult) and Treatment Duration	9
1.7	Cephalometric Predictors for Orthodontic Treatment Duration	9
1.8	Appointment Frequency, Number of Treatment Phases and Treatment Duration	10
1.9	PAR Index as an Assessment of Treatment Outcome	11
	1.9-1 Calculation of PAR Scores	12
	1.9-2 PAR Index Conventions	16
	1.9-3 Validation of PAR Index	17
	1.9-4 Reliability of the Weighted PAR Index	19
	1.9-5 PAR Index and Treatment Success	19
1.10	Limitations of Literature Involving Treatment Duration and the PAR Index	21
1.11	Need for Continued Research	22
1.12	Statement of Objectives	23
1.13	Hypotheses	24
1.14	References	26

Table of Contents

Chapter Two – Research Paper One 30

2.1 Introduction 31

2.2 Methods and Materials 33

2.2-1 Sample 33

2.2-2 Data Collection 35

2.2-3 Reliability 37

2.2-4 Statistical Analysis 37

2.3 Results 38

2.4 Discussion 44

2.5 Conclusions 49

2.6 Appendices 50

Appendix 2.1- Severity weightings for the PAR score components 50

Appendix 2.2- Intra-examiner reliability measurements 50

Appendix 2.3- Intra-examiner PAR correlation assessment 50

2.7 References 51

Table of Contents

Chapter Three – Research Paper Two 54

3.1 Introduction 55

3.2 Methods and Materials 57

3.2-1 Sample 57

3.2-2 Data Collection 59

3.2-3 Reliability 61

3.2-4 Statistical Analysis 61

3.3 Results 62

3.4 Discussion 67

3.5 Conclusions 73

3.6 Appendices 74

Appendix 3.1- Intra-examiner reliability measurements 74

3.7 References 75

Table of Contents

Chapter Four – Discussion and Recommendations 77

4.1 General Discussion of Null Hypotheses and Conclusions 78

4.2 Limitations 80

4.3 Future Investigations 84

4.4 References 86

Table of Contents

Chapter Five – Appendix 89

5.1 Ethics Approval 90

5.2 PAR Index Score Sheet 91

List of Tables

Table No.	Title	Page
Table 1.1	PAR scores for tooth discrepancies	13
Table 1.2	Buccal occlusion PAR scores	14
Table 1.3	PAR scores for overjet	15
Table 1.4	PAR scores for overbite	15
Table 1.5	PAR scores for centerline	16
Table 1.6	Weightings for PAR components (United Kingdom)	18
Table 1.7	Weightings for PAR components (United States)	19
Table 2.1	Selection criteria for patients	34
Table 2.2	Selection criteria for observational groups	34
Table 2.3	Description of sample	36
Table 2.4	Statistics comparing treatment duration for observational groups	38
Table 2.5-1	Treatment duration differences (months)	39
Table 2.5-2	Treatment duration differences (appointments)	39
Table 2.6	Treatment difference (months) with all offices combined	41
Table 2.7	Treatment differences (appointments) with all offices combined	41
Table 2.8	Statistics indicating average number of weeks between appointments	42
Table 2.9	Mean of total treatment time less estimated treatment time (months)	42
Table 2.10	Descriptive statistics for pre-PAR scores and % PAR reduction	43

Table 3.1	Selection criteria for patients	58
Table 3.2	Selection criteria for observational groups	58
Table 3.3	Description of sample	59
Table 3.4	Descriptive statistics for patient, model and cephalometric variables	63
Table 3.5	Descriptive statistics for class II treatment variables	63
Table 3.6	Results from multiple regression of patient variables	64
Table 3.7	Results from multiple regression of model variables	64
Table 3.8	Results from multiple regression of cephalometric variables	65
Table 3.9	Results from multiple regression for treatment variables of class II patients	66
Table 3.10	Treatment time difference (months) between class II appliances	66
Table 3.11	Treatment time difference (months) for maxillary expansion	67

List of Figures

Figure No.	Title of Figure	Page
Figure 1.1	Division of dental arches	12
Figure 2.1	Treatment time (months) comparison between offices	40

Chapter One

Introduction

And

Literature Review

1.1 Introduction

There has been limited research focusing on predicting the orthodontic treatment time for orthodontic patients. Orthodontists have access to many different sources of information when treatment planning (radiographs, clinical exam, photos, and models), and it would be advantageous for the practitioner to know if this information could be used accurately and consistently to predict treatment duration. Some authors believe that accurate prediction of orthodontic treatment length is extremely important for patient satisfaction and overall practice success [1,2]. Shia [1] stressed the need for practitioners to assess their own practice so that they can identify any factors that contribute to treatment overruns. Also, a patient survey by O'Connor has shown the need for orthodontists to be more accurate on their treatment timing estimates [2]. If an orthodontist could be a better predictor of treatment length, then he or she could accurately calculate their overhead costs for specific treatments, and even develop a time-related fee guide. Accurate predictions of treatment time would also increase patient satisfaction when treatment is completed within the estimated time frame.

1.2 Effect of Different Variables on Orthodontic Treatment Duration

Turbill et al. [3] looked at 15 specific variables of patients' treatment within the G.D.S (British National Health Service's General Dental Service) to investigate which factors were associated with treatment duration. They evaluated 1506 orthodontic cases submitted by general dentists and orthodontic specialists within the regions of Wales and England. Characteristics of patients, practitioners, malocclusions, treatment variables,

and outcomes were evaluated. Based on a multivariate analysis, Turbill et al. found that many variables could be linked to longer treatment durations. These variables were:

1) Increased PAR scores (pre-treatment)
2) Increased number of phases
3) Four bicuspid extractions
4) The correction of buccal occlusion
5) Cases with a DHC (Dental Health Component) score of grade 5
6) Treatment provided by an orthodontic specialist rather than a general dentist
7) Use of fixed appliances as opposed to removable appliances
8) Patients in the range of 11-15.99 years of age

Based on their findings, Turbill et al. determined that they could explain 41% of the variance in treatment times.

Beckwith et al. [4] also tried to evaluate factors related to treatment time by examining 31 variables. They gathered full records from 140 consecutively treated patients in 5 different orthodontic offices (28 charts per office). Their study design focused on 4 categories that included 1) patient factors, 2) diagnostic characteristics, 3) treatment modality factors and 4) patient compliance variables. In their analysis they determined that over half of the variation could be explained by six variables (missed appointments, loose brackets and bands, poor oral hygiene, increased number of treatment phases, the prescription of headgear, and between office variables).

In 1996, Taylor et al. [5] studied progress notes and pre and post-treatment models of 156 patients (treated at the Glasgow dental hospital and school), in order to determine which factors were associated with standard and duration of treatment. From this

investigation it was concluded that there was a greater improvement in PAR scores post-treatment when comparing the treatment results of fixed appliances with removable appliances. As well, Taylor et al. also found that females on average, had a three month longer treatment time than males, that extraction of a permanent molar reduced treatment outcome, and that anterior x-bites seemed to be associated with a decrease in treatment time. In conclusion, without scientific significance, the study suggested that a class II division II incisor relationship may lead to increased treatment times.

Fink and Smith [6] also tried to isolate what variables were strongly linked to orthodontic treatment times. Data was studied (total 118 patients) from 6 orthodontic offices and variables were measured from 3 specific categories: 1) patient characteristics, 2) treatment characteristics, and 3) office variables. Based on their data they concluded that there was a significant association of treatment time with pre-treatment ANB, pre-treatment mandibular plane angle, extraction of premolars and the number of broken appointments. Fink and Smith claimed that they could explain 50% of the variation; however, it has been shown by Beckwith et al. [4] that there was an error in their calculation, and more accurately only 24.9% of variance was explained.

In 1973, Myrberg and Thilander [7] wanted to obtain a better clinical understanding of the duration and results of orthodontic treatment. The study involved 1486 children (ages 7-13) with various anomalies that had been treated with different techniques [both removable (60%) and fixed appliances (40%)]. The following variables were studied: 1) uncompleted orthodontic treatment and reason for cessation of treatment, 2) active treatment duration, 3) results of treatment, 4) complete registration period, and 5) duration of retention period. Based on their investigation, Myrberg and Thilander

concluded that there was no significant difference in treatment time between the removable and fixed appliances groups. The study indicated that 35.5% of the group had treatment that usually lasted 1-2 years, with only 4.7% of their sample enduring more than 3 years of active treatment. To assess the results of treatment, Myrberg and Thilander used a subjective 5-grade scale. They reported **good results** in 54.1% of cases, **acceptable results** in 36.9%, and **less poor** or **no response to treatment** in 9% of the cases

1.3 Effect of Extractions on Orthodontic Treatment Duration

It is extremely important for orthodontists to understand the relationship between extractions and overall treatment duration. In 1995 O'Brien et al. [8] focused specifically on the records of 250-class II division I patients to assess the effect of different variables on treatment duration. They concluded that orthodontic treatment involving extractions resulted in longer treatment durations. This research was further continued in 1998, by Vig et al. [9] who studied the records of 994 patients treated at the University of Pittsburgh Graduate Orthodontic Clinic from 1977 to 1991. Although not stated, it is assumed that the subjects from the 1995 [8]study were also included in the data set of the 1998 investigation done by Vig et al. [9]. In this study, the sample had a mixture of class I, class II, and class III patients with 583 cases involving extractions and 411 with no extractions. Based on an ANOVA statistical analysis, Vig et al. determined that extraction treatment on average requires 5 additional months of active orthodontic treatment when compared to the non-extraction group. This is further supported by Fink and Smith [6] who found that treatment time increased 0.9 months per extracted premolar, and also by

Turbill et al. [3] and Alger [10] who both found increased treatment times with extractions.

A certain amount of evidence suggests that extractions increase treatment time; however, not all of the literature is conclusive on this point. In 1990, Vig et al. [11] published mixed results based on the examination of 438 patients from 5 orthodontic offices with varying philosophies regarding extraction and non-extraction treatment. They reported consistently longer treatment lengths for the extraction group over the non-extraction group when looking at the individual offices separately. However, when Vig et al. combined the data from all five offices there was no statistical treatment time difference between extraction and non-extraction patients. Evidently, pooling the data of the five offices together can obscure certain variables affecting treatment duration. These findings are similar to Beckwith et al. [4] who also found that there was no significant difference in treatment duration between extraction and non-extraction treatments.

1.4 Correlation of Malocclusion Severity to Treatment Duration

Many authors have also reviewed the relation of malocclusion severity to treatment time. Grewe and Hermanson [12] looked at the following 3 indices: 1) Handicapping Malocclusion Assessment Record, 2) Occlusal index and 3) Treatment Priority index, and found no significant correlation between the length of treatment and malocclusion severity. Fink and Smith [6] subsequently used the Salzman index to assess severity of malocclusion and found that there was a positive correlation between pre-treatment Salzman scores and the length of treatment. However, it should be noted that the Salzman Index has been criticized for its lack of validity [13]. Another index used to classify the severity of a malocclusion was the PAR index. This index has been shown to

be reproducible and a good approximation of malocclusion severity and treatment difficulty [14-16]. A review of the literature indicates that there appears to be a positive association between treatment time and the pre-treatment PAR score. O'Brien et al. [8] utilized a stepwise regression analysis (250 completed patients at the University of Pittsburgh Graduate Clinic) and learned that the pre-treatment PAR score was associated with an increased treatment duration. Similarly, when Turbill et al. [3] studied 1506 cases for the National Health Services in England and Wales, they also found an association of increased treatment times with the pre-treatment PAR scores. Although the above studies demonstrate a positive association with PAR scores and treatment times, there are other people with the opinion that the predictive value of PAR is still undetermined [3, 5, 8, 17].

1.5 Treatment Duration Associated with Specific Malocclusion Types

Some investigators have attempted to focus on treatment lengths associated with specific malocclusion types. O'Brien et al. [8] looked at 250 class II div I patients treated at the University of Pittsburgh Graduate Orthodontic clinic (between 1977 and 1989). To be classified as a class II division I patient all subjects had to meet the criteria of having a 5mm or greater overjet. It is important to point out that the authors of this study failed to look at molar classification and or skeletal relationship of these patients; therefore, their patient sample may not have been representative of class II patients. The authors examined six specific variables and found significant effects for 1) pre-treatment PAR, 2) number of treatment stages, 3) percentage of appointments attended, 4) number of appliances, and 5) extraction / non-extraction cases.

In 1998, Vig et al. [9] incorporated the same data of the 1995 O'Brien [8] study into a larger investigation designed to further evaluate the outcome of orthodontic treatment. They studied 994 (Angle class I, II, and III) patients treated at the University of Pittsburgh and assessed the duration, occlusal outcome, and relative improvement in dental malocclusion severity. Based on their statistical analysis, Vig et al. found that the treatment of Class II malocclusions required an additional five months (average) compared to the Class I group. Also noted was that the average pre-treatment PAR score was greater in the Class II group (PAR=27.5) than the Class I group (PAR=23.0), thus reinforcing the notion that it usually takes longer to correct the buccal occlusion and overjet [18].

One study in abstract form [19] looked at other possible predictors to explain treatment length between Class I and Class II malocclusions. Vig et al. studied operator characteristics, patient demographics, malocclusion features, treatment variables and changes in pre and post PAR scores. Based on data collected the following were significant:

1) broken appointments have twice the effect in Class II patients compared to Class I patients
2) practitioner years of experience was not predictive for Class I treatment
3) headgear wear increased treatment time for Class I patients but not for Class II patients
4) patient cooperation and compliance decreased treatment time for Class II patients but not Class I patients
5) clinicians with more experience decreased Class II but not Class I treatment length

Furthermore, average pre PAR scores have been shown to increase with a respective increase in malocclusion classification (i.e. Angle Class I, Class II, Class III)[20].

1.6 Patient Age (Adolescent or Adult) and Treatment Duration

Dyer et al. [21] and Robb et al. [18] both studied differences in treatment length between adolescent and adult patients by focusing on specific types of malocclusions. Dyer et al. looked primarily at Class I – 4 bicuspid extraction cases, and Robb et al. concentrated on Class II div I – 4 bicuspid extraction cases. Their results were quite similar as both groups of investigators found no significant treatment time differences between the respective age groups. This was further supported by Beckwith et al. [4] as they also found no orthodontic treatment length differences between child and adult cases.

1.7 Cephalometric Predictors for Orthodontic Treatment Duration

Only a handful of studies have investigated the use of cephalometric values as predictors of orthodontic treatment duration. In 2000, Kim et al. [22] investigated the predictive value of 41 common cephalometric parameters on pre-treatment severity and treatment outcomes. To assess pre-treatment severity, pre-PAR scores were used, and to assess the treatment outcomes, post- PAR, % PAR reduction, and treatment duration were used. After analyzing the data with separate multiple linear regression models, Kim et al. determined that cephalometric parameters could explain the following: 1) 39.2% of pre-treatment severity variance, 2) 17.9 % of post-treatment severity variance, 3) 15.7%

relative treatment improvement, and 4) 20% of treatment duration variance. Of the 41 cephalometric parameters studied, only 2 were statistically significant as predictive values for treatment duration. These were the upper and lower incisors to nasion-A point and nasion-B point respectively.

Beckwith et al.[4] also investigated the possible predictive value of certain cephalometric parameters with treatment duration. Measurements studied included the Saddle angle, the Articular angle, the Gonial angle and the Sum Total Angle of these measurements. However, after multiple regressions it was determined that none of the above cephalometric measures were predictive of orthodontic treatment duration.

Another study investigating cephalometric values as predictive factors for treatment length was completed by Fink and Smith in 1992 [6]. The following were assessed both pre and post-treatment: 1) ANB angles, 2) Md plane angles and 3) upper face height/ lower face height ratios. In conclusion, Fink and Smith found that only the pre-treatment ANB angle and Md plane angle could be used to explain any of the treatment duration variance.

1.8 Appointment Frequency, Number of Treatment Phases and Treatment Duration

Alger [10] appears to be the only person that has studied the relationship between total number of appointments (visits) and orthodontic treatment duration. He examined 92 orthodontic patients whose treatment had been completed at the King Faisal Specialist Hospital and Research Centre (Saudi Arabia) from 1985-1987. During this study Alger saw his patients on a minimum six-week interval, and found that his treatment durations were not significantly greater compared to a three or four week interval. Alger concluded

that with new technology appliances, patients can be seen less often (6 week intervals) without it significantly affecting the total treatment time. It should be noted however, that Alger [10] did not have a control sample for which to base his conclusions. We do not know what the treatment durations on average would be, for patients being seen on a four-week interval.

When looking at the relationship between the number of phases and treatment duration the literature is quite conclusive. Many studies indicate that with an increase in treatment phases there is an increase in total treatment time. [3, 4, 8, 11]

1.9 PAR Index as an Assessment of Treatment Outcome

Orthodontic treatment outcomes are quite variable, with many different opinions of what constitutes a good functional and aesthetic outcome [23]. As a result, numerous occlusal indices have been developed for the assessment of treatment success [24-26]. With regards to occlusal indices of treatment success, the Peer Assessment Rating (PAR) is the only index shown to be reproducible and valid[15, 16]. The PAR index was developed in the United Kingdom (1987) through a series of meetings attended by 10 experienced orthodontists. Over 200 dental casts representative of developmental and pre and post treatment stages were reviewed, until an agreement was reached regarding the occlusal components that should be used to estimate the alignment of occlusion. As a result, the PAR index incorporated the following occlusal components for the assessment of a dental malocclusion:

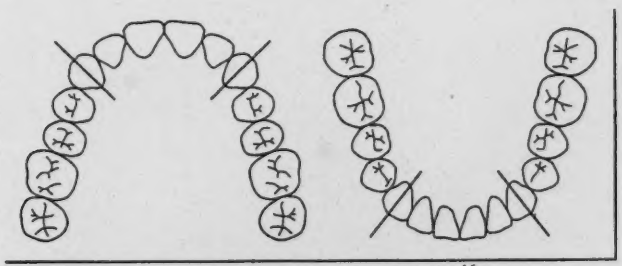
1) Upper right segment
2) Upper anterior segment
3) Upper left segment
4) Lower right segment

5) Lower anterior segment
6) Lower left segment
7) Right buccal occlusion
8) Overjet
9) Overbite
10) Centerline
11) Left buccal occlusion

The PAR is applied to pre and post-treatment dental casts and has been designed to record a malocclusion at all stages of treatment. Individual scores for the various components of the PAR index are eventually summed to calculate an overall final score. A score of zero would indicate ideal alignment and occlusion, where as higher scores would indicate increasing levels of irregularity [27]. The PAR provides an initial estimate of how far a case deviates from normal, and the difference between the before and after treatment scores can be used to determine the degree of improvement with orthodontic treatment [23]. As a result, the PAR index provides both a quantitative and reproducible measure of treatment success.

1.9-1 Calculation of PAR Scores

The dental arch is divided into three recording zones or segments: 1) left buccal, 2) right buccal, and 3) anterior. Scores are recorded for both upper and lower arches (Fig.1.1).



(Fig 1.1, taken from Richmond et al. 1992[16])

Buccal and Anterior Segments

Buccal Segments – The recording zone is from the mesial anatomical contact point of the first permanent molar to the distal anatomical point of the permanent canine.

Anterior Segments – The recording zone is from the mesial anatomical contact point of the permanent canine to the mesial anatomical contact point of the contralateral canine.

The occlusal features recorded in these segments are crowding, spacing and impacted teeth. Displacements (crowding) are recorded as the shortest linear distance between the anatomical contact points of adjacent teeth within the respective zones. The greater the displacement, the greater the PAR scoring. Impactions are recorded when there is less than or equal to 4mm of space available for a particular tooth to erupt. If canines are impacted they are scored in the anterior segment or zone. Spacing is recorded the same way as crowding, by measuring the shortest linear distance between the two adjacent anatomical contact points. Cumulative scores for the impactions and displacements are then added to give an overall score for each recording segment. The scores for discrepancies are shown in Table 1.1.

Score	Discrepancy
0	0 mm to 1 mm
1	1.1 mm to 2 mm
2	2.1 mm to 4 mm
3	4.1 mm to 8 mm
4	Greater than 8 mm
5	Impacted teeth

(Table 1.1, taken from Richmond et al. 1992[16])

Buccal Occlusion

The buccal occlusion is scored with respect to three planes of space (antero-posterior, vertical and transverse). It is recorded on both right and left sides, and the assessment zone extends distally from canine to the last molar (1st, 2nd, or 3rd). All discrepancies are recorded with the teeth in occlusion, and then summed for each buccal occlusion (Table 1.2).

Buccal Occlusion: scored in three planes of space (These measures are summed)	
Score	**Discrepancy**
Antero-Posterior	
0	Good interdigitation Cl I, II, or III
1	Less than Half-unit discrepancy
2	Half of unit discrepancy (cusp to cusp)
Vertical	
0	No discrepancy in intercuspation
1	Lateral open-bite on at least two teeth
Transverse	
0	No cross-bite
1	Cross-bite tendency
2	Single tooth in cross-bite
3	More than one tooth in cross-bite
4	More than one tooth in scissor bite

(Table 1.2, taken from Richmond et al. 1992[16])

Overjet

The overjet recording zone is from left to right lateral incisors. Positive overjet as well as cross-bites are recorded in this section. The most prominent aspect of any one incisor is recorded, and the ruler is held parallel to the occlusal plane (Table 1.3).

Overjet Assessment	
Score	**Discrepancy**
Overjet	
0	0-3 mm
1	3.1-5 mm
2	5.1-7 mm
3	7.1-9 mm
4	Greater than 9 mm
Anterior cross-bites	
0	No discrepancy
1	One or more teeth edge to edge
2	One single tooth in cross-bite
3	Two teeth in cross-bite
4	More than two teeth in cross-bite

(Table 1.3, taken from Richmond et al. 1992[16])

Overbite

This section records the amount of vertical overlap or open bite of the anterior teeth. The recording zone includes the lateral incisors and the teeth with the greatest overlap or open bite (Table 1.4).

Overbite Assessment	
Score	**Discrepancy**
Open Bite	
0	No open bite
1	Open bite less than and equal to 1 mm
2	Open bite 1.1-2 mm
3	Open bite 2.1-3 mm
4	Open bite greater than or equal to 4 mm
Overbite	
0	Less than or equal to one third coverage of the lower incisor
1	Greater than one-third, but less than two-thirds coverage of the lower incisor
2	Greater than two-thirds coverage of the lower incisor
3	Greater than or equal to full tooth coverage

(Table 1.4, taken from Richmond et al. 1992[16])

Centerline

The centerline measurement records the relationship of the upper midline to the midline of the lower central incisors (Table 1.5).

Centreline Assessments	
Score	**Discrepancy**
0	Coincident and up to one-quarter lower incisor width
1	One-quarter to one-half lower incisor width
2	Greater than one-half lower incisor width

(Table 1.5, taken from Richmond et al. 1992[16])

1.9-2 PAR Index Conventions (taken from Richmond et al. 1992[16])

General

1) All scoring is cumulative
2) There is no minimum cut off level
3) Increased overjet, contact point displacements etc. associated with poor restorative work are not recorded.
4) Spaces are not recorded if the patient is to receive a prosthetic replacement.
5) Contact points between deciduous teeth are not recorded.
6) Contact points between first, second and third molars are not recorded.
7) The occlusion should be scored disregarding functional displacement.

Canines

1) Ectopic canines which have erupted in the palate should be recorded as an anterior cross-bite in the overjet section.
2) Where there are missing canines, displacements resulting from discrepancies between the mesial contact of the premolar to distal of the lateral incisor should be recorded in the anterior section.

Impactions

1) If a tooth is unerupted and displaced from the line of the arch either buccally or palatally due to insufficient space, this is regarded as an impaction. However, if the tooth is erupted and displaced, the displacement score is recorded.

Incisors

1) With loss of an incisor due to agenesis, trauma or decay the scoring procedure is as follows: a) if the space is maintained for a prosthesis then it is not scored, or b) if the space is to be closed then this distance is recorded and scored.
2) When recording an overjet, if the tooth falls on the line the lower grade is recorded.
3) If a lower incisor has been extracted or is missing, the centerline is not recorded.

Molars

1) If the first molars have been extracted, the contact point of the second molar is recorded.

1.9-3 Validation of PAR Index

To determine how closely the PAR Index reflected current orthodontic opinion, Richmond et al. [16] devised a method for validation of the PAR. Their goal was to compare a definitive measure of malocclusion using the PAR Index with the mean subjective opinion of regional dentists (England and Wales). They felt that this exercise would provide an opportunity to determine relative weightings for each of the components involved in the PAR. Seventy-four dentists from a regional area were asked to assess and score (on a nine-point scale) a representative sample of 272 dental casts with respect to deviation from normal occlusion. The mean PAR scores for every dental cast were compared to the subjective mean scores from the panel of 74 dentists to determine the correlation between them. Richmond et al. [16, 28] found a correlation of 0.74 between the mean raw PAR scores and the mean subjective scores. When comparing the individual components of the PAR index to the mean subjective scores (panel of 74 dentists) using a regression analysis, certain coefficients could be used to provide weights for each of the PAR components. As a result, some of the PAR components were discarded as they did not have any predictive power. The Pearson Correlation

Coefficient r, was 0.87 for the regression model and 0.85 for the weighted PAR, thus showing a statistically significant higher correlation with the mean deviation from normal occlusion than the unweighted PAR. The coefficient of determination, R^2 for strength of linear association and accuracy was 0.72 for the weighted index. The collective opinion of the 74-dentist panel (United Kingdom) was represented by the following mean weightings in Table 1.6.

Weightings Derived for the 5 Components of the PAR Index	
Components	**Weightings**
1. Upper and lower anterior segment	x 1
2. Left and right buccal occlusions	x 1
3. Overjet	x 6
4. Overbite	x 2
5. Centreline	x 4

(Table 1.6, taken from Richmond et al. 1992[16])

In 1995, DeGuzman et al, [14] attempted to validate the PAR index using a group of orthodontists from the United States. They had eleven orthodontists review a representative sample of two hundred dental casts. Each orthodontist scored the casts using a five point visual analogue scale, for perceived malocclusion severity and treatment difficulty. Using a data analysis similar to Richmond et al. [16, 28] the subjective malocclusion severity and treatment difficulty scores were compared to raw PAR scores. After statistical analysis, DeGuzman et al. reported correlations of the weighted PAR scores with the subjective scores of the orthodontists. Perceived malocclusion severity had a correlation of r = 0.83, and treatment difficulty had a correlation of r = 0.68. The chart below demonstrates the weightings applied to each of the PAR components when

calculating PAR scores to represent an American opinion for malocclusion severity (Table 1.7).

Severity Weightings for the PAR Score Components	
Component of Malocclusion	**Severity Weighting**
Overjet	5
Overbite	3
Midline discrepancy	3
Buccal occlusion	2
Upper anterior alignment	1

(Table 1.7, taken from DeGuzman et al. [14])

1.9-4 Reliability of the Weighted PAR Index

In addition to validating the PAR index in 1992, Richmond et al. [16, 28] also demonstrated the reproducibility of this index. The inter-examiner intraclass correlation coefficient of reliability for the total score for the four examiners was 0.93 with the lower 95 per cent confidence limit of 0.90. The weighted index shows a slight improvement over the unweighted (unweighted r = 0.91, lower confidence limit 0.87). Other studies have further supported the reliability and reproducibility of the PAR index [29, 30].

1.9-5 PAR Index and Treatment Success

In orthodontics it is important to objectively assess whether an improvement has occurred in occlusion and alignment with treatment. The degree of improvement can be assessed using two different methods[28]:

1) **Nomogram**- using this method the pre and post treatment PAR scores are used to assess whether a case fits into one of three categories: 1) Worse or No Different, 2) Improved, and 3) Greatly Improved.

2) **Percentage Improvement**- using this method the change relative to the pre-treatment score is calculated. Percentage improvement also provides a more sensitive assessment than the nomogram, which only provides three broad bands of treatment change.

Richmond et al. [16, 28] have shown that a 30% reduction in weighted PAR scores post-treatment is required for a case to be considered as "improved". They also determined that decrease of 22 points between pre and post PAR scores is necessary to bring about a "great improvement". Therefore, if the mean percentage reduction in PAR score is high and the proportion of cases that have been "greatly improved" is also high, then the practitioner is treating his or her patients to high standard.

1.10 Limitations of Literature Involving Treatment Duration and the PAR Index

After reviewing and critiquing the literature related to this topic, certain weaknesses and limitations were noted. To date, all studies have been retrospective, which creates a certain amount of bias, and some of the studies have shown a large inter-office variation when comparing treatment durations [4, 6, 11]. Well-conducted scientific studies dealing with extraction / non-extraction treatment times are limited; therefore, the influence of extractions on treatment time are still somewhat controversial [4]. Most of the investigations looking at treatment times associated with specific malocclusions were only in *abstract* form [19, 20] with limited or no information about methodology and statistics; therefore, the results from these studies are of questionable validity. As well, many of these studies in question, used patients treated at a graduate orthodontic clinic that might not be representative of a private practice setting. McGuinness and McDonald [31] have shown that the average treatment time for patients treated by more than one operator (ie. graduate clinic) is significantly longer when compared to a single operator.

It should also be noted that using the PAR index to assess standard and difficulty of treatment has its limitations. The PAR doesn't take into account skeletal classification, root angulation, root resorption, decalcification, periodontal breakdown, or degree of finishing [3, 23]. Also, changes to facial profile or cephalometric parameters are not considered in this quantitative evaluation [14], and the PAR index may lack the ability to discriminate between excellent final occlusion and good final occlusion [32]. Despite it's limitations, the PAR is still considered to be the gold standard for evaluating a malocclusion [33]. A review of the current literature certainly demonstrates that the PAR index is presently the most widely used occlusal index to assess malocclusion.

1.11 Need For Continued Research

Based on the limitations of the current literature, future research should focus on decreasing the high amount of variability associated with the investigation of treatment duration. Investigations should incorporate the use of as many controls as possible, to help eliminate the variability between operators and offices when comparing the treatment lengths associated with certain types of malocclusions. Also, groups with a specific malocclusion type (ie: class I or class II) should meet an inclusion criteria to ensure as much homogeneity in the observational groups as possible.

Furthermore, specific pre-treatment cephalometric and model measurements should be investigated to search for any association of these variables with treatment duration. Many orthodontists incorporate different treatment protocols and or materials into their practice, and this could explain some of the inter-office variability shown in previous studies [4, 6, 11]. Finally, very limited work has been done to determine just how accurate orthodontists are in estimating treatment duration for specific types of malocclusions.

As a result, the purpose of this investigation is to determine the relative treatment duration difference (months and number of appointments) between class I non-extraction and class II division I patients (extraction and non-extraction). The estimated treatment length will also be compared to the actual treatment length to determine how accurate the orthodontists were in predicting treatment duration. Furthermore, the final part of the investigation will focus on the relationship of specific variables (model, cephalometric, and treatment variables) to actual treatment duration.

1.12 Statement of Objectives

1) What is the relative treatment duration difference (months) when comparing a simple class I non-extraction group to each of the class II division I groups (extraction and non-extraction)? (Primary Outcome Variable)

2) What is the relative treatment duration difference (appointments) when comparing a simple class I non-extraction groups with each of the class II division I cases (extraction and non-extraction)? (Secondary Outcome Variable)

3) Does the actual treatment length accurately relate to the estimated treatment length in class I and class II patients (extraction and non-extraction)?

4) Are there any clinical variables (patient, model, cephalometric, or treatment) that are predictive of treatment duration in Class II division I patients (extraction and non-extraction)?

1.13 Hypotheses

Hypothesis #1

H_0: There is no relative difference in treatment duration (months) when comparing the class I non-extraction group to each of the class II division I groups (extraction and non-extraction).

Ha: There is a relative difference in treatment duration (months) when comparing the class I non-extraction group to each of the class II division I groups (extraction and non-extraction).

Hypothesis #2

H_0: There is no relative difference in treatment duration (number of appointments) when comparing the class I non-extraction group to each of the class II division I groups (extraction and non-extraction).

Ha: There is a relative difference in treatment duration (number of appointments) when comparing the class I non-extraction group to each of the class II division I groups (extraction and non-extraction).

Hypothesis #3

H_0: The actual treatment duration for the class I non-extraction and class II division I groups (extraction and non-extraction) is not different from the estimated treatment duration.

Ha: The actual treatment duration for the class I non-extraction and class II division I groups (extraction and non-extraction) is different from the estimated treatment duration.

Hypothesis #4

H_0: There are no clinical variables (patient, model, cephalometric or treatment) that can predict treatment duration for class II division I patients (extraction and non-extraction).

Ha: There are clinical variables (patient, model, cephalometric or treatment) that can predict treatment duration for class II division I patients (extraction and non-extraction).

1.14 References

1. Shia GJ. Treatment overruns. J Clin Orthod 1986; 20(9):602-4.

2. O'Connor PJ. Patients' perceptions before, during, and after orthodontic treatment. J Clin Orthod 2000; 34(10):591-2.

3. Turbill EA, Richmond S, Wright JL. The time-factor in orthodontics: what influences the duration of treatments in National Health Service practices? Community Dent Oral Epidemiol 2001; 29(1):62-72.

4. Beckwith FR, Ackerman RJ Jr, Cobb CM, Tira DE. An evaluation of factors affecting duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1999; 115(4):439-47.

5. Taylor PJ, Kerr WJ, McColl JH. Factors associated with the standard and duration of orthodontic treatment. Br J Orthod 1996; 23(4):335-41.

6. Fink DF, Smith RJ. The duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1992; 102(1):45-51.

7. Myrberg N, Thilander B. An evaluation of the duration and the results of orthodontic treatment. Scand J Dent Res 1973; 81(2):85-91.

8. O'Brien KD, Robbins R, Vig KW, Vig PS, Shnorhokian H, Weyant R. The effectiveness of Class II, division 1 treatment. Am J Orthod Dentofacial Orthop 1995; 107(3):329-34.

9. Vig KW, Weyant R, Vayda D, O'Brien K, Bennett E. Orthodontic process and outcome: efficacy studies--strategies for developing process and outcome measures: a new era in orthodontics. Clin Orthod Res 1998; 1(2):147-55.

10. Alger DW. Appointment frequency versus treatment time. Am J Orthod Dentofacial Orthop 1988; 94(5):436-9.

11. Vig PS, Weintraub JA, Brown C, Kowalski CJ. The duration of orthodontic treatment with and without extractions: a pilot study of five selected practices. Am J Orthod Dentofacial Orthop 1990; 97(1):45-51.

12. Grewe JM, Hermanson PC. Influence of severity of malocclusion on the duration of orthodontic treatment. Am J Orthod 1973; 63(5):533-6.

13. Grewe JM, Hagan DV. Malocclusion indices: a comparative evaluation. Am J Orthod 1972; 61(3):286-94.

14. DeGuzman L, Bahiraei D, Vig KW, Vig PS, Weyant RJ, O'Brien K. The validation of the Peer Assessment Rating index for malocclusion severity and treatment difficulty. Am J Orthod Dentofacial Orthop 1995; 107(2):172-6.

15. Richmond S, O'Brien KD, Buchanan IB, Burden DJ. An introduction to occlusal indices. Great Britain: Mandent Press, 1992.

16. Richmond S, Shaw WC, O'Brien KD *et al.* The development of the PAR Index (Peer Assessment Rating): reliability and validity. Eur J Orthod 1992; 14(2):125-39.

17. Tahir E, Sadowsky C, Schneider BJ. An assessment of treatment outcome in American Board of Orthodontics cases. Am J Orthod Dentofacial Orthop 1997; 111(3):335-42.

18. Robb SI, Sadowsky C, Schneider BJ, BeGole EA. Effectiveness and duration of orthodontic treatment in adults and adolescents. Am J Orthod Dentofacial Orthop 1998; 114(4):383-6.

19. Vig K, O'Brien K, Shnorhokian H *et al*. Predictors for Class I & Class II Treatment Duration Differ. 73. 1994:273.

20. Wenger R, Douangpaynya S, Vig K, Beck M, Vig P. Classes I, II and III differences in severity, duration and orthodontic results. 1996:437.

21. Dyer GS, Harris EF, Vaden JL. Age effects on orthodontic treatment: adolescents contrasted with adults. Am J Orthod Dentofacial Orthop 1991; 100(6):523-30.

22. Kim JC, Mascarenhas AK, Joo BH, Vig KW, Beck FM, Vig PS. Cephalometric variables as predictors of Class II treatment outcome. Am J Orthod Dentofacial Orthop 2000; 118(6):636-40.

23. Otuyemi OD, Jones SP. Methods of assessing and grading malocclusion: a review. Aust Orthod J 1995; 14(1):21-7.

24. Eismann D. Reliable assessment of morphological changes resulting from orthodontic treatment. Eur J Orthod 1980; 2(1):19-25.

25. Gottlieb EL. Grading your orthodontic treatment results. J Clin Orthod 1975; 9(3):155-61.

26. Berg R, Fredlund A. Evaluation of orthodontic treatment results. Eur J Orthod 1981; 3(3):181-5.

27. Shaw WC, Richmond S, O'Brien KD. The use of occlusal indices: a European perspective. Am J Orthod Dentofacial Orthop 1995; 107(1):1-10.

28. Richmond S, Shaw WC, Roberts CT, Andrews M. The PAR Index (Peer Assessment Rating): methods to determine outcome of orthodontic treatment in terms of improvement and standards. Eur J Orthod 1992; 14(3):180-7.

29. Buchanan IB, Shaw WC, Richmond S, O'Brien KD, Andrews M. A comparison of the reliability and validity of the PAR Index and Summers' Occlusal Index. Eur J Orthod 1993; 15(1):27-31.

30. Fox NA. The first 100 cases: a personal audit of orthodontic treatment assessed by the PAR (peer assessment rating) index. Br Dent J 1993; 174(8):290-7.

31. McGuinness NJ, McDonald JP. The influence of operator changes on orthodontic treatment times and results in a postgraduate teaching environment. Eur J Orthod 1998; 20(2):159-67.

32. Dyken RA, Sadowsky PL, Hurst D. Orthodontic outcomes assessment using the peer assessment rating index. Angle Orthod 2001; 71(3):164-9.

33. Pae E-K. Measurements must be interval, not ordinal. Angle Orthod 1999; 69:397.

Chapter Two

Research Paper One

Assessment of Class II Treatment Duration

2.1 Introduction

Very limited work has been done to determine how accurate orthodontists are in estimating treatment duration for specific types of malocclusion. Some authors believe that accurate prediction of orthodontic treatment length is extremely important for patient satisfaction and overall practice success [1, 2]. Shia [1] stressed the need for practitioners to assess their own practice so that they can identify any factors that contribute to treatment overruns. Also, a patient survey conducted by O'Connor has shown the need for orthodontists to be more accurate on their treatment timing estimates [2]. If an orthodontist could be a better predictor of treatment length, then he or she could accurately calculate their overhead costs for specific treatments, and even develop a time-related fee guide. Accurate predictions of treatment time would also increase patient satisfaction when treatment is completed within the estimated time frame.

O'Brien et al [3] looked at six possible predictors to explain class II treatment length and found significant effects for: 1) pre PAR, 2) number of treatment stages, 3) percentage of appointments attended, 4) number of appliances, and 5) extraction / non-extraction. In 1998, Vig et al. [4] evaluated patients at the University of Pittsburgh, and found that the treatment of class II malocclusions required an average of 5 additional months compared to the class I group. Also noted was that the average pre-treatment PAR score was greater in the class II group than the class I group, thus reinforcing the notion that it takes longer to correct the buccal occlusion and overjet. [5,6]

Vig et al. [4] determined that extraction treatment requires an additional 5 months of active orthodontic therapy when compared with the non-extraction group. Several studies concur that extractions increase treatment time, [6-8] including Fink and Smith, [8]

who found an average increase of 0.9 months per extracted premolar. In 1990, Vig et al. [9] reported consistently longer treatment lengths for the extraction group over the non-extraction group when looking separately at individual offices with varying philosophies regarding extraction and non-extraction treatment. However, when they combined the data from all five offices there was no statistical treatment duration difference between extraction and non-extraction patients. These findings are similar to Beckwith et al. [10] who also found no significant difference in treatment duration between extraction and non-extraction treatments. Well-conducted scientific studies dealing with extraction and non-extraction treatment durations are limited; therefore, the influence of extractions on treatment times is still somewhat controversial.

Variability between operators and offices have been reported, [8-10] indicating the need for controls when comparing treatment lengths associated with certain types of malocclusions. Also, groups with a specific malocclusion type (Angle class I or class II) should meet an inclusion criteria to ensure as much homogeneity as possible in the observational groups. In addition, many of these studies in question used patients treated at graduate orthodontic clinics that may not be representative of a private practice setting. McGuinness and McDonald [11] have shown that the average treatment time for patients treated by more than one operator (ie. graduate clinic) is significantly longer when compared to a single operator.

The PAR index is used to classify the severity of a malocclusion and has been shown to be reproducible and a good approximation of malocclusion severity and treatment difficulty. [12, 13] Although some studies have indicated that high pre-treatment PAR scores are associated with increased treatment duration, others believe that the

predictive value of the PAR index is still undetermined.[5, 14] The Par Index can also be used to assess treatment outcome by assessing the degree of improvement that has occurred after orthodontic treatment [15].

The purpose of this investigation was to utilize a cohort comparison group (class I non-extraction) from each office to assess the relative treatment duration difference (months and number of appointments) between class II division I patients (extraction and non-extraction) and class I patients. The cohort comparison group was used to normalize the differences between techniques and philosophies of different offices. It was assumed that practitioners treat cases to a treatment goal, which may vary between practices but should be consistent within each practice. In addition, we compared the estimated treatment duration with the actual treatment duration to assess how accurate the orthodontists were in predicting treatment length for specific types of malocclusions. If a standard treatment duration difference between these malocclusion types could be shown, orthodontists would be able to set their fees to reflect the time requirements for treatments, as well as estimate treatment duration more accurately.

2.2 Methods and Materials

2.2-1 Sample

Prior to the initiation of this investigation, approval was granted by the University of Alberta Health Research Ethics Board. This study was conducted in 3 private orthodontic offices in the greater Edmonton area, Alberta, Canada. These practices were selected based on their philosophy to treat most patients with 1 phase of treatment rather than 2 or more phases. All 3 orthodontists involved in the study had at least 10 years of

private practice experience. Patients representing 3 observational groups (Angle class I non-extraction, class II division I extraction and class II division I non-extraction) were selected from the active retention files of each office. The criteria for patient selection is listed below.

Table 2.1 Selection criteria for patients

- Complete records including treatment notes, pre-treatment lateral cephalogram, and pre- and post-treatment models.
- An age range of 10 to 15.99 years at the start of treatment.
- Class II division I and class I patients adhere to Angle's definition of occlusion, and their diagnosis should be clearly indicated in the chart by the practicing orthodontist.
- No history of active orthodontic treatment before full fixed banding (patients were included in the study if they had primary tooth extractions to assist in the general eruption sequence or non-active appliances like a LHA or UHA).
- No missing teeth prior to treatment that would result in an unusual extraction pattern (patients were included in the study if a missing tooth was part of the desired extraction sequence or if the space for a missing tooth was being maintained for a prosthetic restoration).
- No removal of braces prematurely.
- No impacted teeth (requiring surgical uncovering and forced eruption).
- No surgery in conjunction with orthodontic treatment.
- No class II division II incisor patterns.

The selection criteria for the specific observational groups were as follows:

Table 2.2 Selection criteria for observational groups

Class I non-extraction group	• Angle's class I molar bilaterally • Treated without extractions
Class II division I non-extraction group	• ≥ to 5 mm overjet, or ≥ to an ANB angle of 5 degrees • Minimum end to end molar relationship or greater, bilaterally • No extractions
Class II division I extraction group	• ≥ to 5 mm overjet, or ≥ to an ANB angle of 5 degrees • Minimum end to end molar relationship or greater, bilaterally • Extractions of 2 or 4 premolars

2.2-2 Data Collection

The design of this study was unique; therefore, we were unable to perform a sample size calculation using previously published literature. Furthermore, due to a limited number of patient records available, a pilot study to determine sample size was not feasible. As a result, based on a publication by Norman and Streiner [16], the goals for the sample size of each observational group (class I non-extraction, class II division I extraction and non-extraction) was set at 30. Due to a rigid inclusion criteria and limited active retention charts, a minimum of 25 patients for each group was accepted. All available cases that met the selection criteria were included; therefore, randomization of the sample selection was not possible. During the collection of data, the following information was recorded from the patient charts: 1) age of patient, 2) start and finish date of active orthodontic treatment, 3) total number of active treatment appointments, 4) type of class II appliance (Headgear, Herbst, Jasper Jumper, Pendulum), and 5) estimated treatment time as stated by the orthodontist. If the estimated treatment time was recorded as a range, then the upper limit was chosen for this investigation. Also, emergency appointments (ie: poking wire, or loose band) that did not require a full archwire adjustment were not included in the appointment total. A total of 237 patients from the 3 offices were included in the study, and their breakdown into the observational groups is outlined in Table 2.3.

Table 2.3 Description of sample

Class	Office	Number of patients
Class I (non-extraction)	A	26
	B	26
	C	25
Class II (non-extraction)	A	26
	B	30
	C	25
Class II (extraction)	A	26
	B	28
	C	25
TOTAL		237

To ensure blinding during the data collection, the names on the charts, models and pre-treatment lateral cephalograms were covered with a tab indicating an assigned patient number. The patient records were subsequently measured in a randomized order, pre-determined by the Excel (Microsoft Corporation - Seattle, Washington) software package.

The pre-treatment ANB angle was measured to the nearest 0.001 degree, with a KURTA Digitizer (Kurta Corporation – Phoenix, Arizona) using a customized software program developed at the University of Alberta, called CEPH ID. The overjet was measured with a straight ruler to the nearest 0.5mm from the labial surface of the most protrusive maxillary incisor to the labial surface of the corresponding mandibular incisor. The PAR scores for each patient were calculated following the guidelines set by Richmond et al [13, 17] on all pre- and post-treatment models. Subsequently, the PAR scores were then weighted according to DeGuzman et al. [12] to reflect the current American opinion for malocclusion severity (Appendix 2.1).

2.2-3 Reliability

For reliability measurements, 10 sets of records were randomly selected from an Edmonton orthodontic office that was not used in the main study. Intra-examiner reliability was determined by randomly measuring the overjet and PAR scores on the 10 pre-treatment models. In addition, the pre-treatment ANB angle was measured on the 10 pre-treatment lateral cephalograms. These models and lateral cephalograms were measured on three separate occasions, with a one-week interval between sessions. All of the models and cephalograms were blinded with the technique described previously, and then randomly measured by the principal investigator.

Based on an ANOVA calculation, it was determined that there was no significant difference for any of the model or pre-treatment ANB measurements between the three sessions. These results indicate that there was excellent intra-examiner reliability (Appendix 2.2). In addition, the Pearson correlation coefficients for the PAR scores displayed a very high correlation with r-values of 0.97 and greater (Appendix 2.3).

2.2-4 Statistical Analysis

After collection of all data, the information will be viewed graphically to ensure it is normally distributed. The average difference in treatment duration (months and total number of appointments) will be compared between the class I and class II patients in each office. A Bonferroni Test of Multiple Comparisons (ANOVA) will then be used to determine significance at a p value of 0.05. Subsequently, a Contrast in Multiple Regressions (ANOVA) will compare the average treatment duration difference between the 3 offices.

Descriptive statistics will demonstrate the average difference in months between the estimated and the actual treatment duration for each of the observational groups. Contrast Tests (ANOVA) will then be used to determine the p values associated with the differences between the observational groups. A response will be considered significant if the p value is ≤ 0.05.

2.3 Results

Graphic evaluation of the data demonstrated normal distribution. The descriptive statistics in Table 2.4 includes the average total treatment duration (months / appointments) and the standard deviations of the observational groups within the 3 offices.

Table 2.4 Statistics comparing treatment duration for observational groups

Class	Office	Mean treatment time (months)	Range (months)	Standard deviation (months)	Mean # of appts.	Standard deviation (appts.)
Class I (non-extraction)	A	23.814	14.5 – 29.0	3.2515	17.69	2.923
	B	19.897	11.7 – 35.7	5.5909	14.00	4.109
	C	16.928	8.5 – 32.3	6.5891	12.96	4.296
Class II (non-extraction)	A	23.894	10.6 – 31.3	3.8732	18.38	3.837
	B	30.186	17.9 – 41.1	6.0110	22.00	4.299
	C	22.087	9.4 – 36.0	7.2183	16.76	5.356
Class II (extraction)	A	24.450	16.1 – 29.6	2.7019	17.08	2.529
	B	24.913	13.7 – 39.1	5.4971	17.29	3.961
	C	25.605	11.3 – 34.8	7.4289	18.24	4.245

A Bonferroni Test of Multiple Comparisons (Avova) was used to determine the relative treatment duration difference (months / appointments) among the observational groups within the 3 offices. (Tables 2.5-1 and 2.5-2) The mean difference in months / appointments between the groups was reported, along with the standard errors and p values. A p value ≤ 0.05 was considered to be significant.

2.5-1 Treatment duration difference (months)

Office	(i) Class	(j) Class II	Mean diff. (i-j) (months)	Standard error (months)	P value	Overall Power
A	I	II non-exo	-.080	.92	.999	
	I	II exo	-.64	.92	.999	.094
	II non-exo	II exo	-.56	.92	.999	
B	I	II non-exo	-10.29*	1.53	.001*	
	I	II exo	-5.02*	1.56	.005*	.990
	II non-exo	II exo	5.27*	1.50	.002*	
C	I	II non-exo	-5.16*	2.00	.036*	
	I	II exo	-8.68*	2.00	.001*	.975
	II non-exo	II exo	-3.52	2.00	.250	

*The mean difference is significant at the .05 level.

2.5-2 Treatment duration difference (appointments)

Office	(i) Class	(j) Class II	Mean diff. (i-j) (appts.)	Standard error (appts.)	P value	Overall Power
A	I	II non-exo	-.69	.872	.999	
	I	II exo	.62	.872	.999	.241
	II non-exo	II exo	1.31	.872	.414	
B	I	II non-exo	-8.00*	1.11	.001*	
	I	II exo	-3.29*	1.13	.014*	.990
	II non-exo	II exo	4.71*	1.09	.001*	
C	I	II non-exo	-3.80*	1.32	.016*	
	I	II exo	-5.28*	1.32	.001*	.961
	II non-exo	II exo	-1.48	1.32	.796	

* The mean different is significant at the .05 level.

In office A, there was no significant relative treatment duration difference (months / appointments) between any of the three groups. (Tables 2.5-1, 2.5-2)

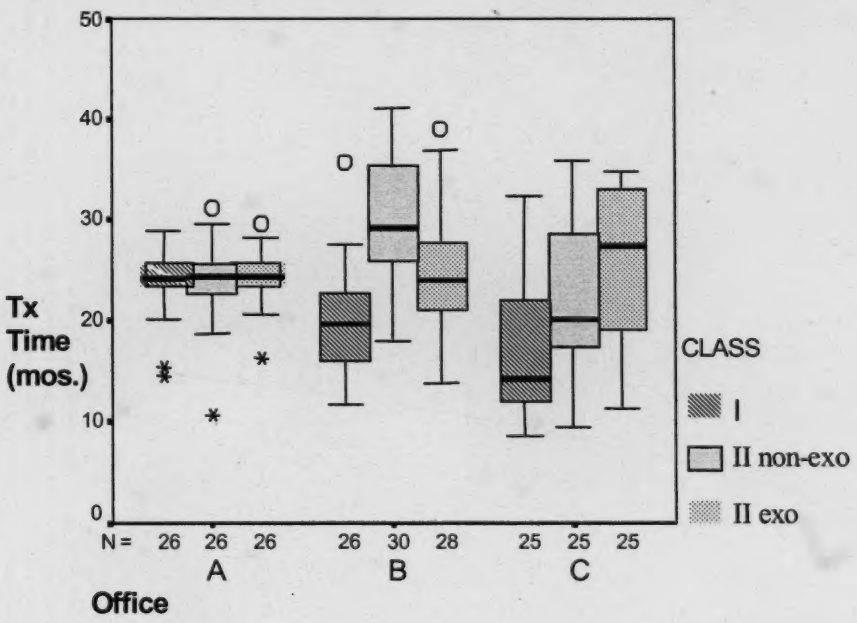
In office B, there was a significant relative treatment duration difference (p value ≤ 0.05) when comparing the class I group (cohort comparison group) to the class II extraction and non-extraction groups. Similarly, office B also displayed a significant difference (p value ≤ 0.05) in relative treatment length when comparing the class II extraction and class II non-extractions groups (Tables 2.5-1, 2.5-2).

In office C, there was a significant relative treatment length difference (p value $\leq$ 0.05) when comparing the class I group (cohort comparison group) to the class II

extraction and class II non-extraction groups. When comparing the difference between the two class II groups there was no significant difference in relative treatment time (months / appointments) (Tables 2.5-1, 2.5-2).

The difference of the mean treatment time (months) for the observational groups is represented by the following boxplot (Fig. 2.1).

Figure 2.1 Treatment time (months) comparison between offices



A Contrast in Multiple Regression (ANOVA) was used to compare the relative treatment duration differences (months / appointments) between the 3 offices. The relative treatment duration difference (months / appointments) between the class I and the class II non-extraction group was significantly different between each office, with p values ≤ 0.05. Similarly, the relative treatment duration difference (months /

appointments) between the class I and the class II extraction groups were all significantly different, except between offices B and C.

In Tables 2.6 and 2.7, the data from the 3 offices was grouped together and analyzed by Bonferroni Tests of Multiple Comparisons (ANOVA) to determine any significant differences (months / appointments) between the observational groups. Results with p values ≤ 0.05 were considered statistically significant.

Table 2.6 Treatment difference (months) with all offices combined

(i) Class	(j) Class II	Mean diff. (i-j) (months)	Standard error (months)	P value (months)	Overall power
I	II non-exo	-5.41*	.971	.001*	
I	II exo	-4.72*	.971	.001*	0.99
II non-exo	II exo	.687	.971	0.99	

*The mean difference is significant at the .05 level

Table 2.7 Treatment difference (appointments) with all offices combined

(i) Class	(j) Class II	Mean diff. (i-j) (appts.)	Standard error (appts.)	P value (appts.)	Overall power
I	II non-exo	-4.31*	.692	.001*	
I	II exo	-2.61*	.692	.001*	0.99
II non-exo	II exo	1.70*	.692	.042*	

*The mean difference is significant at the .05 level

Descriptive statistics indicating the average number of weeks between appointments for each of the observational groups (class I non-extraction, class II non-extraction, class II extraction) is included in Table 2.8.

Table 2.8 Statistics indicating average number of weeks between appointments

Class	Office	Average time between appts. (weeks)	Standard deviation (weeks)
Class I (non-extraction)	A	5.81	.52
	B	6.23	1.37
	C	5.55	.78
Class II (non-extraction)	A	5.70	1.05
	B	5.89	.45
	C	5.66	.88
Class II (extraction)	A	6.20	.65
	B	6.26	.95
	C	5.96	.83

With the use of a Bonferroni Test of Multiple Comparisons (ANOVA), the mean difference between the actual and estimated treatment times was reported for each of the observational groups in the study (Table 2.9). Standard deviations and p values were also presented, and variables were considered significant if the p value was ≤ to 0.05.

Table 2.9 Mean of total treatment time less estimated treatment time (months)

Office	Class	Mean estimated Tx time (months)	Mean of total Tx – est. Tx (months)	Standard Deviation	P value	Overall Power
A	I	23.63	-.03	3.43	.96	
	II non-exo	23.85	.12	3.72	.87	.071
	II exo	24.00	.45	2.70	.40	
B	I	23.87	2.86*	4.39	.003*	
	II non-exo	22.16	6.25*	5.33	.001*	.928
	II exo	22.58	1.48	4.89	.12	
C	I	22.72	.97	5.48	.39	
	II non-exo	21.88	3.37*	7.05	.025*	.309
	II exo	21.54	4.01*	7.00	.009*	

*The mean difference is significant at the .05 level

Based on the data in Table 2.9, it is evident that the orthodontists significantly ($p < .05$) underestimated treatment length for 4 of the 9 observational groups. When considering the number of patients in each observational group per office, it appears that the orthodontists from offices B and C significantly underestimated the actual treatment length in 66.6% of their patients.

The pre-treatment PAR scores and percentage PAR reduction (U.S weighting) for all of the observational groups are shown in Table 2.10

Table 2.10 Descriptive statistics for pre- PAR scores and % PAR reduction

		Pre-Tx PAR (U.S.)		% PAR reduction (U.S.)	
Office	Class	Mean	Std. Dev.	Mean	Std. Dev.
A	I	13.534	4.25	86.05	17.32
	II non-exo	22.23	6.81	60.14	28.18
	II exo	27.73	7.66	55.93	22.24
B	I	19.50	6.70	74.02	16.55
	II non-exo	31.29	7.11	71.96	14.17
	II exo	34.29	8.83	70.87	19.34
C	I	20.04	8.53	71.11	30.83
	II non-exo	29.56	6.18	83.61	12.15
	II exo	32.08	8.14	77.60	14.93

When comparing class I groups between the offices, office A demonstrated a significantly ($p < 0.01$) lower pre-treatment PAR score compared to offices B and C (power = 0.934). There was no significant difference in PAR percentage reduction between any of the 3 offices.

The comparison of the class II non-extraction groups demonstrated that office B had a significantly higher pre-treatment PAR score compared to office A ($p < 0.001$), but not to office C. Also, office A had a significantly lower pre-treatment PAR score ($p < 0.001$) than the other 2 offices (power = 0.995). Analysis of the percentage PAR

reduction for the class II non-extraction group indicated that only office C had a significantly higher percentage reduction ($p < 0.001$) than office A (power = 0.962).

When comparing the class II extraction groups, office B demonstrated a significantly higher pre-treatment PAR when compared to office A (power = 0.741). Analysis of the percentage PAR reduction indicated that office A had a significantly lower percentage reduction ($p < 0.05$) when compared to the other 2 offices (power = 0.963).

Descriptive statistics involving class II appliances, indicated that offices A and C exclusively used headgear for class II correction; whereas, office B primarily used the Herbst appliance for class II correction. By focusing on office B, we found that the Herbst appliance was used 25 times for the class II non-extraction group, and only 4 times for the class II extraction group. This difference in Herbst use was found to be statistically significant by use of a Chi-Square test ($p \leq 0.05$). In addition, we found that class II appliances were used 68 times in the class II non-extraction group and only 39 times in the class II extraction group.

2.4 Discussion

Previous studies have reported inter-office variability when comparing treatment durations for certain malocclusions [8-10]. In this investigation, a cohort comparison group (class I group) was compared with class II groups (extraction and non-extraction), in order to determine a relative treatment duration difference (months / appointments) between various malocclusions. It was assumed that each orthodontist would employ a similar treatment philosophy and degree of finishing for both their class I and class II cases. Despite efforts to reduce the amount of inter-office variability with a cohort

comparison group; no standard treatment duration difference (months or appointments) between these malocclusion types could be determined.

It is important to point out, that when we analyzed the offices individually the difference in appointments between observational groups closely mimicked the differences in months. This can be explained by the fact that all of the offices maintained a similar time interval of approximately 6 weeks between appointments. As a result, appointments and months were grouped together for discussion purposes in this paper.

Based on descriptive statistics, office A was shown to have a higher average treatment duration for the class I group (23.8 months / 17.7 appointments), than office B (19.9 months / 14.0 appointments) or office C (16.9 months / 13.0 appointments). A longer class I treatment for office A could be related to a difference in treatment philosophy from the other orthodontists. If the orthodontist had different views on treatment such as banding second molars, use of expansion appliances, elastic wear, and degree of orthodontic finishing, this could explain the observed variance in treatment duration. It should be noted that a post-hoc power analysis for sample size revealed low values for office A. Due to the surprisingly small differences in treatment length (months/ appts.) between the class I and class II patients in this office, a very large sample size would have been necessary to determine any significant occurrences.

In office B, the class II non-extraction group averaged 30.2 months (22.0 appointments) of total treatment duration, a substantial difference from the 24.8 months reported for the class II non-extraction group in O'Brien et al.'s study [3]. The class II non-extraction group of office B was also significantly longer than the same observational groups in offices A and C, which reported average treatment lengths of 23.9 months (18.4

appts.) and 22.1 months (16.8 appts.) respectively. This difference was most likely related to the type of class appliance used for growth modification between offices. Offices A and C exclusively used headgear, whereas office B primarily used the Herbst appliance. The Herbst appliance was used mainly for the class II non-extraction group of office B, which explains the observed difference in treatment length compared to offices A and C. Furthermore, the Herbst appliance was often preceded by maxillary sutural expansion to allow for the proper insertion and function of this appliance; such an additional step may also have contributed to treatment delay.

With the data combined from all 3 offices, there was a significant treatment difference (months/ number of appointments) when comparing the class I group to each of the class II groups (non-extraction and extraction). Both class II groups took approximately 5 months longer to treat in comparison to the class I group, which was similar to the difference Vig et al. [4] observed in their sample. When assessing the difference between the class II groups there was no significant difference in months; however, there was a significant difference in number of appointments. The class II non-extraction group averaged 1.70 more appointments than the class II extraction group, which was significant with a p value $\leq .05$. A possible explanation for this finding could be related to the use of class II appliances for growth modification. The non-extraction group used more class II appliances than the extraction group; therefore, the difference in appointments may have been related to the extra visits required for the insertion and activation of such appliances.

By comparing the actual treatment length of patients to the estimated treatment duration, we found that the orthodontists significantly underestimated treatment length in

4 of the observational groups. These under-estimations were found to be significant for class I and class II non-extraction groups in Office B, and for the class II non-extraction and extraction groups in Office C. Basically, 2 of the 3 orthodontists in this study significantly underestimated treatment time for 66.6% of their patients. Therefore, it is reasonable to deduct the need for better tools to help predict treatment length for specific malocclusions. This is not a surprising result, as a survey by O'Connor [2] has shown the need for orthodontists to be more accurate on their treatment timing estimates.

Offices A and C demonstrated no significant treatment time difference between class II extraction and non-extraction patients. Beckwith et al [10] concurs with these results as they also found that extractions did not significantly affect treatment lengths. In office B, there was a significant difference between the class II groups with the non-extraction group requiring 5.27 months longer than the extraction group. This result was surprising, as previous literature has shown that extraction treatment generally takes longer than non-extraction treatment. [6-8] Our data demonstrated that the Herbst appliance was used significantly more in the non-extraction group than the extraction group, thus indicating the association of this appliance with longer treatment duration. There appears to be no consensus regarding the effect of extractions on treatment duration.

The findings of this study indicate no association between treatment length and pre-treatment PAR scores. As a result, our investigation does not support the claims of other studies that found an association between treatment length and pre-treatment PAR scores [3, 6]. The use of percentage PAR reduction to assess treatment outcome [15, 17] was also not predictive of treatment length in our study. Even though the class I group in office A demonstrated a longer treatment time and greater percentage PAR reduction than

the other 2 offices, it was not statistically significant. Furthermore, the pre-treatment PAR scores in office A were significantly less than the other two offices, in all occasions except one. These low scores might be explained by the fact that office A is located in a higher socio-economic region where clients may seek treatment for malocclusions that are less severe in nature.

Overall, this investigation was limited by a relatively small sample size that was restricted to specific regional area (greater Edmonton area). It would have been advantageous to incorporate larger numbers of offices located across a greater geographical area (ie: Canada); however, due to time constraints and limited resources, this was not possible. To help explain some of the variability associated with class II treatment, it would also be beneficial to compare offices that used the same appliance for class II correction. The introduction of different class II appliances (ie: Herbst) may have resulted in skewed treatment results. In addition, the PAR index used in this investigation to assess malocculsion severity and treatment outcome may not be sensitive enough to detect small differences in finished orthodontic cases (marginal ridges, tooth angulation, gingival health) [6, 18]. Finally, designing this study to be done prospectively rather than retrospectively would help decrease any bias related to patient selection.

2.5 Conclusions

1) Between the 3 individual orthodontic offices, no standard treatment duration difference (months / appointments) could be determined between the class I and either of the class II groups (extraction and non-extraction).
2) When comparing estimated treatment lengths to the actual treatment lengths, it was discovered that the orthodontists significantly underestimated the treatment duration for 4 of the 9 observational groups. This indicated that 2 of the 3 orthodontists underestimated the actual treatment length in 66% of their cases.
3) In this investigation, extraction treatment (months) was not significantly longer than non-extraction treatment (months) for class II division I patients.
4) Pre-treatment PAR scores and percentage PAR reduction were not associated with treatment length.

Based on the results of this investigation, it is recommended that every orthodontist do their own practice evaluation to determine the average treatment time differences between specific malocclusions. This would provide the necessary information to develop a time related fee guide for different malocclusions. In addition, it would help orthodontists be more accurate at estimating their treatment times. To further explain which factors most strongly affect treatment time variation, correlation statistics could be conducted to assess the relationship between outcome measures (PAR reduction, post Par scores) and treatment time (actual and estimated).

2.6 Appendices

Appendix 2.1

Severity weightings for the PAR score components

Severity Weightings for the PAR Score Components	
Component of Malocclusion	**Severity Weighting**
Overjet	5
Overbite	3
Midline discrepancy	3
Buccal occlusion	2
Upper anterior alignment	1

DeGuzman et al. 1995[12]

Appendix 2.2

Intra-examiner reliability measurements

Variable differences between sessions**	Sum of squares	Df	Mean square	F	Sig.
Overjet	.350	2	.175	1.370	.271
ANB	.330	2	.165	.367	.696
PAR	6.667	2	3.333	1.098	.348

* p-values less than 0.05 were considered statistically significant
** 3 measurement sessions were performed at1-week intervals

Appendix 2.3

Intra-examiner PAR correlation assessment

PAR session		PAR week 1	PAR week 2	PAR week 3
PAR week 1	Pearson Correlation	1.000	.983**	.971**
	Sig. (2-tailed)	.	.000	.000
PAR week 2	Pearson Correlation	.983**	1.000	.979**
	Sig. (2-tailed)	.000	.	.000
PAR week 3	Pearson Correlation	.971**	.979**	1.000
	Sig. (2-tailed)	.000	.000	.

** Correlation is significant at the .01 level (2-tailed)

2.7 References

1. Shia GJ. Treatment overruns. J Clin Orthod 1986; 20(9):602-4.

2. O'Connor PJ. Patients' perceptions before, during, and after orthodontic treatment. J Clin Orthod 2000; 34(10):591-2.

3. O'Brien KD, Robbins R, Vig KW, Vig PS, Shnorhokian H, Weyant R. The effectiveness of Class II, division 1 treatment. Am J Orthod Dentofacial Orthop 1995; 107(3):329-34.

4. Vig KW, Weyant R, Vayda D, O'Brien K, Bennett E. Orthodontic process and outcome: efficacy studies--strategies for developing process and outcome measures: a new era in orthodontics. Clin Orthod Res 1998; 1(2):147-55.

5. Robb SI, Sadowsky C, Schneider BJ, BeGole EA. Effectiveness and duration of orthodontic treatment in adults and adolescents. Am J Orthod Dentofacial Orthop 1998; 114(4):383-6.

6. Turbill EA, Richmond S, Wright JL. The time-factor in orthodontics: what influences the duration of treatments in National Health Service practices? Community Dent Oral Epidemiol 2001; 29(1):62-72.

7. Alger DW. Appointment frequency versus treatment time. Am J Orthod Dentofacial Orthop 1988; 94(5):436-9.

8. Fink DF, Smith RJ. The duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1992; 102(1):45-51.

9. Vig PS, Weintraub JA, Brown C, Kowalski CJ. The duration of orthodontic treatment with and without extractions: a pilot study of five selected practices. Am J Orthod Dentofacial Orthop 1990; 97(1):45-51.

10. Beckwith FR, Ackerman RJ Jr, Cobb CM, Tira DE. An evaluation of factors affecting duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1999; 115(4):439-47.

11. McGuinness NJ, McDonald JP. The influence of operator changes on orthodontic treatment times and results in a postgraduate teaching environment. Eur J Orthod 1998; 20(2):159-67.

12. DeGuzman L, Bahiraei D, Vig KW, Vig PS, Weyant RJ, O'Brien K. The validation of the Peer Assessment Rating index for malocclusion severity and treatment difficulty. Am J Orthod Dentofacial Orthop 1995; 107(2):172-6.

13. Richmond S, Shaw WC, O'Brien KD *et al*. The development of the PAR Index (Peer Assessment Rating): reliability and validity. Eur J Orthod 1992; 14(2):125-39.

14. Taylor PJ, Kerr WJ, McColl JH. Factors associated with the standard and duration of orthodontic treatment. Br J Orthod 1996; 23(4):335-41.

15. Richmond S, Shaw WC, Roberts CT, Andrews M. The PAR Index (Peer Assessment Rating): methods to determine outcome of orthodontic treatment in terms of improvement and standards. Eur J Orthod 1992; 14(3):180-7.

16. Norman GR, Streiner DL. Biostatistics: the bare essentials. Hamilton, ON: B.C. Decker, 1998.

17. Richmond S, O'Brien KD, Buchanan IB, Burden DJ. An introduction to occlusal indices. Great Britain: Mandent Press, 1992.

18. Otuyemi OD, Jones SP. Methods of assessing and grading malocclusion: a review. Aust Orthod J 1995; 14(1):21-7.

Chapter Three

Research Paper Two

Predictors for Class II Treatment Duration

3.1 Introduction

In the orthodontic profession, it is difficult to accurately predict treatment times for specific malocclusions. Shia [1] stressed the need for orthodontists to evaluate their own practices to determine what factors are responsible for treatment overruns. Since orthodontists have access to various types of information during the treatment planning stage (models, radiographs, clinical exam, photos), it would be very beneficial to know which factors could be used as predictors of treatment time. Unfortunately, due to limited research in this field, there seems to be no consensus as to what predictors, if any, could be used to reliably predict treatment duration. Accurate predictions would not only help orthodontists establish a time-related fee guide for specific malocclusions, but would also increase patient satisfaction and overall practice success [1 2]. O'Connor [2] conducted a survey on patient satisfaction and found the need for orthodontists to be more accurate on treatment time estimates; this suggests that further research would help orthodontists recognize and predict the effect that specific factors have on treatment length.

Turbill et al. [3] evaluated the effects of patient characteristics, practitioners, malocclusions, and treatment variables on total treatment length. Based on their analysis of 15 variables, they could explain 41% of the variance in treatment time. Beckwith et al. [4] also evaluated possible factors related to treatment duration that included: 1) patient factors, 2) diagnostic factors, 3) treatment modality factors, and 4) patient compliance variables. Based on this data, over half of the variation could be explained by six variables: 1) missed appointments, 2) loose brackets and bands, 3) poor oral hygiene, 4) increased number of treatment phases, 5) prescription of headgear, and 6) between office variables. Fink and Smith [5] also looked at patient characteristics, treatment

characteristics, and office variables for connections to treatment length. They found a significant association between treatment time and pre-treatment ANB, pre-treatment Md plane angle, extraction of premolars and number of broken appointments.

Several studies have tried to determine the effect that extractions have on treatment duration. O'Brien et al [6] focused on class II division I patients and concluded that orthodontic treatment involving extractions leads to longer treatment times. Vig et al. [7] determined that extraction treatment takes an additional 5 months, and Fink and Smith [5] found that treatment time increased 0.9 months per extracted premolar. In addition, Turbill et al. [3] and Alger [8] both found increased treatment times with extractions. Contrary to the above studies, Vig et al. [9] found no statistically significant treatment time difference between extraction and non-extraction patients when they combined the data from 5 offices. Similarly, Beckwith et al. [4] found no significant difference in treatment duration between extraction and non-extraction patients. The effect of extractions on treatment time is still somewhat controversial due to a lack of well-controlled studies.

Some investigations have concentrated on treatment lengths associated with specific malocclusions. O'Brien et al. [6] focused their investigation on class II division I patients and found that the following affected treatment time: 1) pre-treatment PAR scores, 2) number of treatment phases, 3) percentage of appointments attended, 4) number of appliances, 5) and extraction / non-extraction cases. Vig et al. [7] also assessed the duration, occlusal outcome, and relative improvement in malocclusion severity for Angle class I, II, and III patients. From their data, they concluded that class II treatment required an additional 5 months compared to the class I group. In addition, pre-treatment

PAR was higher in the class II group than the class I group, reinforcing the notion that it takes longer to correct the buccal occlusion and overjet in orthodontic patients. [3 10]

Attempts have been made to determine whether cephalometric values could be used as predictors of orthodontic treatment duration. Kim et al. [11] investigated the predictive value of common cephalometric parameters on pre-treatment severity and treatment outcomes. With 41 cephalometric parameters studied, only the upper and lower incisors to N-A point and N-B point were significant. Similarly, Fink and Smith [5] only found pre-treatment ANB and Md plane angles significant for treatment time. Beckwith et al. [4] looked at the Saddle Angle, Articular Angle, Gonial Angle, and the total sum of all these measurements and found no significant effects.

In this investigation, specific criteria were used to include class I (non-extraction) and class II division I (extraction and non-extraction) patients from 3 orthodontic offices. The purpose of this study was to identify any clinical variables (patient, model, cephalometric and treatment) that may predict treatment length for class II division I malocclusions. If orthodontists had a better understanding of the variables associated with treatment length, it would enable them to be more accurate in treatment estimations.

3.2 Methods and Materials

3.2-1 Sample

Prior to the initiation of this investigation, approval was granted by the University of Alberta Health Research Ethics Board. This study was conducted in 3 private practice orthodontic offices in the greater Edmonton area, Alberta, Canada. Selection of these particular offices was based on their philosophy to treat most patients with 1 phase of

treatment rather than 2 or more phases. The orthodontists from each of the offices used in this study had a minimum 10 years of orthodontic private practice experience. The active retention patients included from each office represented 3 observational groups (Angle class I non-extraction, class II division I non-extraction, and class II division I extraction). The criteria for patient selection is listed below.

Table 3.1 Selection criteria for patients

- Complete records including treatment notes, pre-treatment lateral cephalogram, and pre- and post-treatment models.
- An age range of 10 to 15.99 years at the start of treatment.
- Class II division I and class I patients adhere to Angle's definition of occlusion and their diagnosis should be clearly indicated in the chart by the practicing orthodontist.
- No history of active orthodontic treatment before full fixed banding (patients were included in the study if they had primary tooth extractions to assist in general eruption sequence or non-active appliances like a LHA or UHA).
- No missing teeth prior to treatment that would result in an unusual extraction pattern (patients were included in the study if a missing tooth was part of the desired extraction sequence or if the space for a missing tooth was being maintained for a prosthetic restoration).
- No removal of braces prematurely.
- No impacted teeth (requiring surgical uncovering and forced eruption).
- No surgery in conjunction with orthodontic treatment.
- No class II division II incisor patterns.

The selection criteria for the specific observational groups were as follows:

Table 3.2 Selection criteria for observational groups

Class I non-extraction group	• Angle's class I molar bilaterally • Treated without extractions
Class II division I non-extraction group	• ≥ to 5 mm overjet, or ≥ to an ANB angle of 5 degrees • Minimum end to end molar relationship or greater, bilaterally • No extractions
Class II division I extraction group	• ≥ to 5 mm overjet, or ≥ to an ANB angle of 5 degrees • Minimum end to end molar relationship or greater, bilaterally • Extractions of 2 or 4 premolars

3.2-2 Data Collection

Due to a limited number of active retention files and the rigid inclusion criteria, it was difficult to gather large numbers of patient files for each observation group (class I non-extraction, class II extraction and class II non-extraction). As a result, the sample size achieved, reflected all available patient files that fit our selection criteria. Due to the inherent restrictions associated with achieving a large sample size; randomization of these study subjects was not possible. The total sample size among the 3 orthodontic offices was 237, and the following Table 3.3 provides a breakdown of patients for each observational group.

Table 3.3 Description of sample

Class	Office	Number of patients
Class I (non-extraction)	A	26
	B	26
	C	25
Class II (non-extraction)	A	26
	B	30
	C	25
Class II (extraction)	A	26
	B	28
	C	25
TOTAL		237

During data collection, information was recorded from patient treatment records (charts, models, and lateral cephalograms).

1) **Patient information-** age and gender

2) **Model information-** overjet and overbite

3) **Pre-treatment lateral cephalogram information**- ANB, Palatal plane (ANS-PNS) to SN, Mx incisor to palatal plane, Md incisor to Md plane (Go-Me), Md plane angle to SN.

4) **Treatment information**- start and finish date of active orthodontic treatment, type of class II appliance used (Headgear, Herbst, Jasper Jumper, Pendulum), number of months class II appliance was used, number of months inter-arch elastics were used, use of expansion appliance (yes/no), months into treatment when second molars were banded, premolar extractions (yes/no), closing mechanics (sliding or closing loops), number of debonds, number of missed appointments, and average length between appointments (weeks).

***Note**: A cancelled appointment was not considered missed if it was rescheduled within a one week time period. Also, repositioning a bracket to change tooth position was included in the total number of debonds.

Before data collection, names on the charts, pre-treatment lateral cephalograms and models, were covered with a tab indicating an assigned patient number. This procedure ensured blinding during the data collection stage. The patient numbers were then measured in a randomized order that was pre-determined by the Excel (Microsoft Corporation - Seattle Washington) software used in this investigation.

Using a KURTA Digitizer (Kurta Corporation – Phoenix Arizona), and a customized software program (University of Alberta) called CEPH ID, all pre-treatment cephalometric values were measured to the nearest 0.001 degree. The overjet was measured with a straight ruler to the nearest 0.5mm from the labial surface of the most protrusive maxillary incisor to the corresponding mandibular incisor. The overbite value

was obtained with the same straight ruler to the nearest 0.5mm, by measuring the mandibular incisal edge to a pencil line drawn parallel to the occlusal plane, located at the point of greatest overlap.

3.2-3 Reliability

Ten sets of records were randomly selected from an orthodontic office within the city of Edmonton. The office used for the reliability measurements was not part of the main investigation. Intra-examiner reliability was determined by randomly measuring the cephalometric values, overjet and overbite on 10 pre-treatment lateral cephalograms and models. The models and lateral cephalograms were measured on three separate occasions with a one-week interval between sessions. All of the models and cephalograms were blinded and randomly measured by the principal investigator.

Based on ANOVA calculations, it was determined that there were no significant differences for any model or cephalometric measurements between the 3 sessions (Appendix 3.1). These results indicate that there was excellent intra-examiner reliability.

3.2-4 Statistical Analysis

After collection of the information, all of the data will be viewed graphically to ensure it is normally distributed. For statistical data analysis in this study, the independent variables will be grouped into specific categories. These categories consist of: 1) patient variables 2) model variables, 3) cephalometric variables, and 4) class II treatment variables. Separate multiple regressions will be used to analyze each specific category to determine which variables are significantly associated with total treatment

length. Since the patient, model, and cephalometric variables are not specific to class II treatment, their regressions will be calculated from a data set that includes the class I and class II patients from all 3 offices. Conversely, when the treatment variables are examined, only the class II patients from the 3 offices will be included. A p value ≤ 0.05 will be considered statistically significant. In addition, ANOVA and T-Tests will be conducted to determine the difference in treatment duration (months) between the different class II appliances, as well as between maxillary expansion versus non-expansion.

3.3 Results

Graphic evaluation of the data demonstrated normal distribution. Descriptive statistics indicating the values for the patient, model and cephalometric variables between the various observation groups (class I non-extraction, class II non-extraction and class II extraction) are shown in Table 3.4.

Table 3.4 Descriptive statistics for patient, model, and cephalometric variables

Independent Variables (patient, model, and cephalometric)	Class I non-extraction	Class II non-extraction	Class II extraction
Mlale (# / %)	34 (44.2%)	38 (46.9%)	34 (43%)
Female (# / %)	43 (55.8%)	43 (53.1%)	45 (57%)
Office A (# / %)	26 (33.8%)	26 (32.1%)	26 (32.9%)
Office B (# / %)	26 (33.8%)	30 (37.0%)	28 (35.4%)
Office C (# / %)	25 (32.5%)	25 (30.9%)	25 (31.6%)
Age- yrs. (SD) Mean	13.25 (1.32)	12.4 (1.28)	12.57 (1.31)
Tx duration- months (SD)	20.25 (5.96)	25.7 (6.78)	24.97 (5.48)
Tx duration- appts. (SD)	14.91 (4.29)	19.2 (5.0)	17.52 (3.64)
Overjet- mm (SD) Mean	3.38 (1.40)	7.00 (2.40)	7.59 (2.22)
Overbite- mm (SD) Mean	3.46 (2.01)	4.01 (1.37)	3.63 (1.57)
ANB- (SD) Mean	3.27 (2.07)	5.81 (1.89)	6.35 (1.95)
PP to SN (SD) Mean	-8.69 (4.04)	-7.27 (3.36)	-8.02 (3.42)
Mx Inc. to PP (SD) Mean	113.33 (6.22)	114.14 (5.97)	114.48 (7.88)
Md Inc. to MP (SD) Mean	92.17 (6.28)	96.84 (7.47)	98.34 (9.41)
SN to MP (SD) Mean	35.64 (6.01)	33.13 (5.39)	35.88 (5.70)

SD = standard deviation

Descriptive statistics indicating the values for the class II treatment variables between the class II observation groups (class II non-extraction and class II extraction) are shown in Table 3.5.

Table 3.5 Descriptive statistics for class II treatment variables

Independent Variables (Class II treatment)	Class II non-extraction	Class II extraction	Combined class II groups
Use of Mx expansion appl.- yes (# / %)	24 (29.6%)	6 (7.6%)	30 (18.8%)
Pts. with second molars banded (# / %)	21 (25.9%)	23 (29.1%)	44 (27.5%)
Pts. with premolar extractions (# / %)	0 (0%)	79 (100%)	79 (49.4%)
Use of sliding mechanics (# / %)	65 (80.2%)	40 (50.6%)	105 (65.6%)
Use of closing loops (# / %)	16 (19.8%)	39 (49.4%)	55 (34.4%)
Class II appl. type- (# / %)			
Headgear	41 (50.6%)	35 (44.3%)	76 (47.5%)
Herbst	25 (30.9%)	4 (5.1%)	29 (18.1%)
Jasper Jumper	1 (1.2%)	0 (0%)	1 (0.6%)
Pendulum	1 (1.2%)	0 (0%)	1 (0.6%)
Months of Cl II appl. wear- mean (SD)	12.50 (5.45)	12.38 (7.54)	12.46 (6.23)
Months of Inter-arch els. wear- mean (SD)	10.05 (5.98)	13.42 (7.34)	11.86 (6.93)
Tx – length months (SD) mean	25.7 (6.78)	24.97 (5.48)	25.32 (6.16)
Tx – length appts. (SD) mean	19.2 (5.0)	17.52 (3.64)	18.38 (4.45)
Number of debonds- mean (SD)	2.95 (3.07)	1.52 (1.80)	2.24 (2.62)
Number of missed appts. - mean (SD)	0.80 (1.08)	1.11 (1.44)	0.96 (1.28)
Average length between appts. - weeks (SD)	5.76 (0.81)	6.15 (0.82)	5.95 (0.84)

SD = standard deviation

A multiple regression analysis was done to determine which patient variables (age, and gender) were significantly related to total treatment duration. For analysis of the patient variables the class I and class II patients from all 3 offices were grouped together. Based on the regression analysis only patient age was significantly related to orthodontic treatment duration. Age displayed a p value < 0.001 and an R^2 value of 2.9% (Table 3.6).

Table 3.6 Results from multiple regression of patient variables

R square = .029			
Variable	**p-value**	**Regression coefficient**	**Overall power**
Age*	.009**	-.827	0.751

*p-value less than .05 is significant

A multiple regression analysis was done to determine which model variables (overjet and overbite) were significantly related to total treatment duration. For analysis of the model variables, the class I and class II patients from all 3 offices were combined. Based on the regression analysis, overjet was the only variable found to be significantly associated with total treatment duration. Overjet displayed a p value < 0.001 and an R^2 value of 10.6% (Table 3.7).

Table 3.7 Results from multiple regression of model variables

R square = .106			
Variable	**p-value**	**Regression coefficient**	**Overall power**
Overjet*	.0001*	.769	.990

*p-value less than .05 is significant

The cephalometric variables were also assessed to determine their relationship with total treatment duration. A multiple regression was done which included the class I

and class II patients from all three offices. Based on the results, only the pre-treatment ANB angle was found to be significantly associated with total treatment length. The pre-treatment ANB variable had a p value < 0.001 and a R^2 value of 6% (Table 3.8).

Table 3.8 Results from multiple regression of cephalometric variables

R square = .060			
Variable	**p-value**	**Regression coefficient**	**Overall power**
Pre-Tx ANB*	.0001*	.675	.971

* p-value less than .05 is significant

For analysis of the treatment variables, only the class II patients from the 3 offices were included. Due to a limited number of patients with second molars banded, this variable was not included in our investigation. Similarly, the Jasper Jumper and Pendulum appliances (class II appliance types) were only used once throughout the whole patient sample; therefore, they were also not factored into the regression model. Based on the class II patients, a multiple regression was conducted and 6 variables were found to be significantly associated with class II treatment time. Our analysis also indicated that the average time (weeks) between appointments, total debonds, and months of elastic and class II appliance wear, all had positive regression coefficients. The R^2 value for this regression model was 57.6% and any p values ≤ 0.05 were considered statistically significant (Table 3.9).

Table 3.9 Results of multiple regression for treatment variables of class II patients

R square for the group = .576			
Variable	**p-value**	**Regression coefficient**	**Overall power**
Maxillary expansion*	.020*	---------	.649
Class II appl. type*	.0001*	---------	.990
Months of elastics*	.0001*	.324	.990
Months of Class II appl.*	.003*	.206	.840
Total debonds*	.006*	.378	.797
Avg. time between appts.*	.0001*	2.04	.997

* p value less than .05 is significant

A Bonferroni Pairwise Comparison test (ANOVA) was used to analyze some of the significant variables identified in Table 3.9. The type of class II appliance had a significant affect on total treatment time. The average treatment time for class II patients varied, dependant on the type of class II appliance (Table 3.10). It should be noted that the group treated without a class II appliance consisted mainly of class II extraction patients, where the class II correction was achieved with controlled space closure and inter-arch elastics. Furthermore, in the class II extraction patients where only the upper bicuspids were removed, the class II molar relationship was not corrected.

Table 3.10 Treatment time difference (months) between class II appliances

(i) Class II appliance	(j) Class II appliance	Mean diff. (i-j) (months)	Standard error (months)	p-value	Overall power
Herbst	Headgear	9.097*	1.325	.0001*	
Herbst	No class II appl.	6.864*	1.436	.0001*	.990
No class II appl.	Headgear	2.233	1.193	.063	

*The mean difference is significant at the .05 level

Our results indicated that class II treatment involving maxillary expansion also had a significant association with total treatment time. Based on a Pairwise Comparison test (ANOVA), we found that the maxillary expansion group took on average an extra

2.642 months to treat than the non-expansion group. This result was statistically significant with a p value = 0.020 (Table 3.11).

Table 3.11 Treatment time difference (months) for maxillary expansion

(i) Mx expansion appl.	(j) Mx expansion appl.	Mean diff. (i-j) (months)	Standard error (months)	P value	Overall power
Yes	No	2.642*	1.120	.020*	.649

* The mean difference is significant at the .05 level.

To ensure that our class II regression model was robust, we incorporated the significant variables from the 4 previous regressions into a combined regression model (these included age, overjet, pre-treatment ANB, maxillary expansion, class II appliance type, months of elastics, months of class II appliance, total debonds and average time (weeks) between appointments). In the combined class II regression model, age, overjet and pre-treatment ANB were not significant, supporting the results of the original class II regression model.

Power calculations done on all of the statistics used in this study, indicated that the sample size for this investigation was adequate.

3.4 Discussion

Based on the analysis of the patient variables, only patient age was found to be significantly associated with treatment length. The negative regression coefficient meant that treatment duration decreases as the age increases, and the small R^2 value (2.9%) indicated that only a small percentage of the variance could be explained. Some possible explanations for these findings could be related to the start of orthodontic treatment before all the permanent teeth have erupted. Another explanation could be based on the

assumption that patients mature more with age. Patients with an increased maturity level might be better cooperators, which could lead to decreased treatment lengths for specific malocclusions.

When we assessed the effect of model variables on treatment time, only overjet and over bite were evaluated. Based on our results, overjet was significantly associated with total treatment length; however, with an R^2 value of 10.6%, only a small portion of the treatment variance could be explained. Furthermore, when we evaluated the cephalometric variables, only the pre-treatment ANB angle had a significant association with treatment time. It too had a small R^2 value and only explained 6% of the treatment variance. A larger overjet and ANB angle is often associated with class II division I malocclusions, which based on our investigation, were found to have a longer treatment duration than the class I malocclusions. These results are supported by Vig et al. [7] who determined that class II treatment on average takes 5 months longer than class I treatment. Furthermore, Fink and Smith [5] also demonstrated a significant association of the pre-treatment ANB with treatment length. Consequently, these results support the notion that it takes longer to correct the buccal occlusion and overjet in orthodontic patients. [3 10] Other cephalometric results from this investigation are contrary to Fink and Smith [5], who found a significant effect for the Md plane angle on treatment duration. With the exception of the pre-treatment ANB angle, there appears to be no consensus in the literature regarding cephalometric predictive values for treatment duration.

The main objective of this study was to assess treatment predictors by focusing on class II treatment duration in the three orthodontic offices. Based on our results, the following treatment variables were found to be significantly related to treatment time:

1) type of class II appliance, 2) maxillary expansion, 3) number of months class II appliance was used, 4) number of months of inter-arch elastic wear, 5) total debonds and 6) average time between appointments (weeks).

The class II appliance type and use of maxillary expansion were both related to treatment duration. Our data indicated that the use of the Herbst appliance over the headgear, resulted in an average increased treatment time of 9.097 months. A possible explanation for the difference between these two appliances is that maxillary expansion is routinely required prior to the insertion of the Herbst appliance. When maxillary expansion was incorporated into the treatment plan, the treatment length was 2.642 months longer in comparison to patients treated without maxillary expansion. It is important to note that these differences were found to be statistically significant after accounting for the other six treatment variables (significant) in the class II regression model.

The number of months of class II appliance and inter-arch elastic wear was significantly linked to treatment length in class II patients. These results seem logical, as one would expect to use inter-arch elastics and class II appliances (growth modification) longer in class II cases that are more severe (greater discrepancy in buccal occlusion and overjet). Also, these results could be a reflection of patient cooperation. For patients who do not wear their appliances (i.e. headgear or inter-arch elastics) for the prescribed time, the treatment correction will take longer. Shia [1] concurred with these findings, as he found poor patient cooperation to be one of the primary reasons for treatment overruns.

Total number of debonds also displayed a significant association with increased treatment length. In our investigation, the number of debonds included occasions where

the bracket was knocked off the tooth and required replacement. Also included was the occasional repositioning of a bracket to improve tooth angulation and/or alignment. In both of these situations, the orthodontist might have to slow down treatment progression by temporarily decreasing wire size for re-alignment of the teeth. Furthermore, the need to replace brackets that have been knocked off due to unfavorable activities or eating habits, could also be a reflection of poor patient cooperation.

In this study, the average time (weeks) between appointments was found to be significantly associated with increased treatment duration. Even though this association was statistically significant, the r-value of 0.340 indicated a weak correlation; therefore, the clinical relevance of this association may be limited. In 1988, Alger [8] found no significant treatment duration differences between longer (6 week) and shorter (4 week) appointment intervals. It should be noted, however, that Alger did not have a control sample of patients treated on a 4 week recall, for which to base his conclusions.

Previous investigations examining different variables with multiple regressions [4,5] have claimed that missed appointments are significantly associated with longer treatment times. The current investigation does not support their claims, as missed appointments had no significant effect on treatment time for the class II patients of this study. Furthermore, Cadman et al. [12] found that Canadian First Nations patients missed more appointments than non-First Nations patients; however, when assessing the treatment lengths between these two groups, no significant differences were found. It is important to note that Cadman et al. found no significant differences in post treatment PAR scores between First Nations and non-First Nations patients.

The present study supported the findings of Beckwith et al. [4] and Vig et al. [9] that extractions did not significantly influence the duration of treatment. These results are contrary to other studies, that found extractions significantly affected treatment length [3 5 7 8]. Vig et al.[7] found extractions increased treatment time by 5 months, and Fink and Smith [5] determined that treatment length increased 0.9 months per extracted premolar. The effect that extractions have on treatment length still remains controversial.

Collectively, the significant class II treatment variables in this study explained 57.6% of the variance in treatment length. This result was higher than the variance explained by previous investigations that also looked at treatment length predictors [3-5]. A possible explanation for this result could be our attempt to make the class II groups as homogenous as possible. All of the class II patients used in this investigation had to meet a strict selection criterion, to ensure that they represented similar malocclusions among the three offices.

When considering the overall R^2 value of 57.6%, it is important to note that a large portion of the class II treatment length variance remains unexplained. Some of the factors that have been left out of this investigation include the variable rates associated with jaw growth and bone remodeling between patients. In addition, the application of different tooth forces in combination with different materials (i.e. heat activated wires, TMA, NiTi coils) may also have contributed to the variance in treatment duration. Since some of these factors would be extremely challenging to measure, a complete explanation of all treatment variance associated with class II malocclusions may be difficult to achieve.

Overall, one of the limitations of the current investigation was the retrospective nature of the study design. A prospective study would have been advantageous in reducing bias; however, due to limited time restraints and resources this was not possible. Furthermore, our results were determined on a sample of patients that were grouped together from 3 orthodontic offices. The treatment was provided by different orthodontists, which added inter-office variability to the sample.

3.5 Conclusions

Based on the results of this study using patients from 3 orthodontic offices, the following can be concluded:

1. After examination of the patient variables (age and gender) for the class I and class II patients, only age was significantly related to treatment length.
2. After assessing specific model variables (overjet and overbite) for class I and class II patients, only overjet contributed significantly to an increase in treatment time.
3. After examining specific cephalometric variables for class I and class II patients, only the pre-treatment ANB contributed significantly to an increase in treatment time.
4. After assessing specific treatment variables for class II patients, the following were found to significantly increase treatment time: a) type of class II appliance, b) number of months of class II appliance wear, c) number of months of inter-arch elastic wear, d) maxillary expansion, e) number of debonds and f) average length (weeks) between appointments.
5. When maxillary expansion was done, the average treatment length significantly increased by 2.6 months, after the other six treatment variables (significant) were accounted for in the class II regression model.
6. The use of the Herbst appliance compared to a headgear, resulted in an average increase in the treatment time of 9.1 months, after the other 6 treatment variables (significant) were accounted for in the class II regression model.
7. The 6 significant treatment variables for class II patients explained 56.7% of the variance in treatment length.
8. Further research is needed to help explain more of the treatment length variance.

3.6 Appendices

Appendix 3.1

Intra-examiner reliability measurements

Variable differences between sessions**	Sum of squares	Df	Mean square	F	Sig.
Overjet	.350	2	.175	1.370	.271
Overbite	.217	2	.108	.409	.668
Md plane-SN	2.293	2	1.147	1.251	.302
Wits	1.867	2	.933	1.046	.365
ANB	.330	2	.165	.367	.696
SN-PP	2.764	2	1.382	1.083	.353
Mx I-PP	34.638	2	17.319	3.131	.060
Md I-Md plane	8.424	2	4.212	2.077	.145

* p-value less than 0.05 were considered statistically significant
** 3 measurement sessions were performed at1-week intervals

3.7 References

1. Shia GJ. Treatment overruns. J Clin Orthod 1986; 20(9):602-4.

2. O'Connor PJ. Patients' perceptions before, during, and after orthodontic treatment. J Clin Orthod 2000; 34(10):591-2.

3. Turbill EA, Richmond S, Wright JL. The time-factor in orthodontics: what influences the duration of treatments in National Health Service practices? Community Dent Oral Epidemiol 2001; 29(1):62-72.

4. Beckwith FR, Ackerman RJ Jr, Cobb CM, Tira DE. An evaluation of factors affecting duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1999; 115(4):439-47.

5. Fink DF, Smith RJ. The duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1992; 102(1):45-51.

6. O'Brien KD, Robbins R, Vig KW, Vig PS, Shnorhokian H, Weyant R. The effectiveness of Class II, division 1 treatment. Am J Orthod Dentofacial Orthop 1995; 107(3):329-34.

7. Vig KW, Weyant R, Vayda D, O'Brien K, Bennett E. Orthodontic process and outcome: efficacy studies--strategies for developing process and outcome measures: a new era in orthodontics. Clin Orthod Res 1998; 1(2):147-55.

8. Alger DW. Appointment frequency versus treatment time. Am J Orthod Dentofacial Orthop 1988; 94(5):436-9.

9. Vig PS, Weintraub JA, Brown C, Kowalski CJ. The duration of orthodontic treatment with and without extractions: a pilot study of five selected practices. Am J Orthod Dentofacial Orthop 1990; 97(1):45-51.

10. Robb SI, Sadowsky C, Schneider BJ, BeGole EA. Effectiveness and duration of orthodontic treatment in adults and adolescents. Am J Orthod Dentofacial Orthop 1998; 114(4):383-6.

11. Kim JC, Mascarenhas AK, Joo BH, Vig KW, Beck FM, Vig PS. Cephalometric variables as predictors of Class II treatment outcome. Am J Orthod Dentofacial Orthop 2000; 118(6):636-40.

12. Cadman KC, Glover KE, Heo G, Warren S, Major PW. Orthodontic treatment outcome in a First Nations population in Alberta, Canada: A comparative study. Am J Orthod Dentofacial Orthop 2002; 121:396-402.

Chapter Four

Discussion

And

Recommendations

4.1 General Discussion of Null Hypotheses and Conclusions

Null Hypothesis #1

H_0: There is no relative difference in treatment duration (months) when comparing the class I non-extraction group to each of the class II division I groups (extraction and non-extraction).

In this investigation, it was determined that there was a significant relative treatment length difference (months) between the class I non-extraction group and each of the class II division I groups (extraction and non-extraction). Based on these results, the null hypothesis was rejected. When the data was analyzed further, it was noted that office A behaved quite differently from offices B and C. As a result, the relative difference in treatment length (months) between the class I and class II groups, was evaluated separately in each office. By comparing these differences (months) among the 3 offices, we found that no standard treatment length difference (months) existed between the class I and each of the class II groups (extraction and non-extraction).

Null Hypothesis #2

H_0: There is no relative difference in treatment duration (number of appointments) when comparing the class I non-extraction group to each of the class II division I groups (extraction and non-extraction).

In this investigation, it was determined that there was a significant relative treatment length difference (appointments) between the class I non-extraction group and each of the class II division I groups (extraction and non-extraction). Based on these results, the null hypothesis was rejected. When the data was analyzed further, it was

noted that office A behaved quite differently from offices B and C. As a result, the relative difference in treatment length (months) between the class I and class II groups, was evaluated separately in each office. By comparing these differences (appointments) among the 3 offices, we found that no standard treatment length difference (appointments) existed between the class I and each of the class II groups (extraction and non-extraction).

Null Hypothesis #3

H_0: The actual treatment duration for the class I non-extraction and class II division I groups (extraction and non-extraction) is not different from the estimated treatment duration.

In this investigation, all of the observational groups between the 3 offices, were looked at individually. Based on our results, it was determined that the orthodontists significantly underestimated the actual treatment duration in 4 of the 9 observational groups. Since all of these significant findings were evenly distributed between offices B and C, it was concluded that 2 of the 3 orthodontists underestimated the actual treatment length for 66.6% of their cases. As a result, this null hypothesis was rejected.

Null Hypothesis #4

H_0: There are no clinical variables (patient, model, cephalometric or treatment) that can predict treatment duration for class II division I patients (extraction and non-extraction). Based on a multiple regression analysis, it was determined that 6 treatment variables (class II specific) were significantly associated with class II division I treatment length.

These 6 class II treatment variables were found to be predictive of treatment duration and they explained 57.6% of the variance. Therefore, the stated null hypothesis was rejected.

4.2 Limitations

Previous investigations have reported large amounts of inter-office variability when assessing treatment length for different malocclusions [1-3]. In the current study, a cohort comparison group internal (class I non-extraction) was compared with class II groups (extraction and non-extraction) in order to reduce variability by comparing the relative treatment time difference between offices. Based on our investigation, no standard treatment time difference (months or appointments) between offices could be determined for the class II extraction and non-extraction groups. Despite our efforts, the results of our investigation concurred with previous studies, as we found significant inter-office variation between the 3 offices. To help explain the variation further, a larger sample size would have been beneficial. With a larger patient pool in each of the observational groups, we may have determined a better understanding of what factors significantly influence treatment duration. In addition, it would have been ideal to have a larger number of offices involved in the study. Our focus on 3 orthodontic offices represented a relatively small regional area that did not provide us with a broad spectrum of practice variation. It would have been beneficial to have a representation of offices from across Canada. Unfortunately, due to limited resources and time constraints, this was not possible in the scope of the current investigation.

Another weakness of the current investigation was the failure to look more closely at the effects of patient cooperation on orthodontic treatment duration. Shia [4] determined

poor patient cooperation to be one of the primary causes for treatment overruns. No instrument or method was used in this study to assess how well patients complied with the instructions from the orthodontist. In addition, the effect of oral hygiene on treatment length was not assessed. Our investigation looked at limited variables related to patient cooperation, but was not designed to provide unequivocal evidence on this issue. Based on a regression analysis of our data, we found that treatment length was significantly associated with the number of months that inter-arch elastics and class II appliances were used. Unfortunately, we were not sure if these results were due to the severity and difficulty of the class II malocclusion, or to poor patient cooperation. In this investigation, we also determined that the total number of debonds was significantly associated with class II treatment length. Since the cause of debonds was not recorded, we were unable to conclude if these results were due to poor patient cooperation, operator experience, or bonding material failure. In addition, missed appointments were also assessed in the current investigation. Several studies have found a significant association between missed appointments and increased treatment times [2, 3]. In fact, Gross et al. [5] reported that irresponsible appointment keeping could result in less effective treatment and unnecessarily extended treatment periods. The results from the current study cannot support this claim, as missed appointments were found to have no significant affect on treatment length. It should be noted however, that patients debanded prematurely were not included in the current study. As a result, bias was introduced in the patient selection process that may have skewed the effects of poor compliance (hygiene, missed appointments, etc.) on treatment length. Future studies need to be conducted

prospectively, and should focus on developing a better tool to accurately assess cooperation.

In the current study, the PAR index was used to provide both a quantitative and reproducible measure of treatment success [6-8]. Some studies have found longer treatment times associated with a higher pre-treatment PAR score [9, 10]; however, in this investigation treatment length was not associated with PAR. Furthermore, the treatment success as measured by percentage reduction in PAR, was also unable to find an association with the different treatment lengths reported in our study. Unfortunately, using the PAR index to assess standard and difficulty of treatment has its limitations. The PAR doesn't take into account skeletal classification, root angulation, root resorption, decalcification, periodontal breakdown or degree of finishing [9, 11]. Also, changes to facial profile or cephalometric parameters are not considered in this quantitative evaluation [12], and the PAR index may lack the ability to discriminate between excellent final occlusion and good final occlusion [13]. Consequently, a system or index that assesses the results of orthodontic treatment more precisely (ie: ABO criteria) may have provided more valuable information.

Due to limited time constraints and resources, this investigation was done retrospectively. The problem with any retrospective study is that bias can be a factor during the selection of the study subjects. In the current investigation, bias may have played a role in the selection of class I and class II patients. With strict patient selection criteria, some of the variables responsible for treatment length may have eliminated. Ideally, a prospective study with clearly defined selection criteria, would have decreased

the amount of bias and accounted for any patients that prematurely discontinued treatment.

As part of the patient selection criteria, the current investigation limited all patients to a pre-treatment (adolescent) age of 10 to 15.99 years. Adult patients were not included in the study; however, several studies have shown no treatment time difference between adults and adolescents [2, 14, 15]. One potential problem with the age range in the current study could be that the patient's dental age differs from their chronological age [16]. As a result, the stage of dental development at the start of treatment may be an important factor in the explanation of treatment length [2]. For example, if a patient started treatment prior to the second molars erupting, there could be a delay in treatment progression, if further into treatment these molars require bonding or banding.

The 3 offices used in this investigation exhibited a high degree of treatment time variation between them. This study made no attempt to match the offices based on similar treatment approaches, philosophy or appliance selection. By assessing the practices prior to selection to ensure they followed similar treatment protocols, we may have been able to eliminate the variability between them. This investigation found that the expansion of the maxilla and use of the Herbst appliance significantly affected treatment duration. If we could have selected offices that used the same class II appliance and had the same philosophy regarding maxillary expansion, we may have reduced the inter-office variability dramatically.

4.3 Future Investigations

Further investigation in this field should focus on doing a well-controlled prospective study to determine other factors associated with treatment length. This would help to reduce the inherent amount of bias associated with a study that is retrospective in nature. Furthermore, a larger sample size, representing a large geographical region (ie: Canada) would provide a broader spectrum of practice variation for which to base any conclusions. A study designed in this manner might be able to provide orthodontists with the predictors necessary to provide accurate treatment estimates.

In the current investigation, we focused on class I and class II division I patients. Future studies could investigate the relationship of various factors to the treatment length associated with class II division II and class III patients. Also, studies could be continued to assess any treatment predictors on patients with more severe skeletal discrepancies that require orthognathic surgery. It might be very interesting to know the effects that certain treatment decisions have on treatment time (ie: 1 or 2 jaw surgery, segmental mechanics, and post-surgical leveling). In addition, the current investigation focused only on patients treated with one phase of treatment. Studies could be done in the future to compare the treatment lengths of similar groups treated with 1 phase, or 2 phases of orthodontic treatment.

Based on the current investigation, weaknesses were noted with regards to assessment of patient cooperation and orthodontic treatment outcome (PAR index). Future investigations to determine better tools for the measurement and assessment of patient cooperation would be extremely valuable. Perhaps some type of standardized

charting and scoring system could be developed to indicate a patient's level of cooperation throughout treatment. In addition, a more detailed occlusal and esthetic index to assess treatment outcome might help explain future treatment length differences. Such factors as marginal ridge heights, tooth angulations, root parallelism, gingival health, and facial esthetics could be examined post-treatment to measure the degree of orthodontic finishing.

In the current investigation, we made the assumption that the goal of the orthodontists was to treat their patients to the best possible outcome, regardless of treatment length. If practitioners varied from this attitude or were influenced by other factors (ie. patient / parent pressures, or financial pressures) it may explain some of the variance in treatment length between offices. Future studies could investigate the association of treatment length with differing orthodontic opinions regarding what constitutes a successful treatment outcome.

Finally, other areas of future research should focus on advances made in the technology of orthodontic materials. It would be very beneficial to have well-controlled studies comparing the treatment lengths using self-ligating brackets versus conventional brackets. Furthermore, it would also be interesting to know the effects that nickel-titanium coils have on treatment times, compared to elastomeric chains and closing loops. There are several opportunities for continued research of treatment length variation when dealing with new material technology.

4.4 References

1. Vig PS, Weintraub JA, Brown C, Kowalski CJ. The duration of orthodontic treatment with and without extractions: a pilot study of five selected practices. Am J Orthod Dentofacial Orthop 1990; 97(1):45-51.

2. Beckwith FR, Ackerman RJ Jr, Cobb CM, Tira DE. An evaluation of factors affecting duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1999; 115(4):439-47.

3. Fink DF, Smith RJ. The duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1992; 102(1):45-51.

4. Shia GJ. Treatment overruns. J Clin Orthod 1986; 20(9):602-4.

5. Gross AM, Bishop FW, Reese D *et al*. Increasing patient compliance with appointment keeping. Am J Orthod Dentofacial Orthop 1988; 93(3):259-60.

6. Richmond S, O'Brien KD, Buchanan IB, Burden DJ. An introduction to occlusal indices. Great Britain: Mandent Press, 1992.

7. Richmond S, Shaw WC, O'Brien KD *et al*. The development of the PAR Index (Peer Assessment Rating): reliability and validity. Eur J Orthod 1992; 14(2):125-39.

8. Richmond S, Shaw WC, Roberts CT, Andrews M. The PAR Index (Peer Assessment Rating): methods to determine outcome of orthodontic treatment in terms of improvement and standards. Eur J Orthod 1992; 14(3):180-7.

9. Turbill EA, Richmond S, Wright JL. The time-factor in orthodontics: what influences the duration of treatments in National Health Service practices? Community Dent Oral Epidemiol 2001; 29(1):62-72.

10. O'Brien KD, Robbins R, Vig KW, Vig PS, Shnorhokian H, Weyant R. The effectiveness of Class II, division 1 treatment. Am J Orthod Dentofacial Orthop 1995; 107(3):329-34.

11. Otuyemi OD, Jones SP. Methods of assessing and grading malocclusion: a review. Aust Orthod J 1995; 14(1):21-7.

12. DeGuzman L, Bahiraei D, Vig KW, Vig PS, Weyant RJ, O'Brien K. The validation of the Peer Assessment Rating index for malocclusion severity and treatment difficulty. Am J Orthod Dentofacial Orthop 1995; 107(2):172-6.

13. Dyken RA, Sadowsky PL, Hurst D. Orthodontic outcomes assessment using the peer assessment rating index. Angle Orthod 2001; 71(3):164-9.

14. Dyer GS, Harris EF, Vaden JL. Age effects on orthodontic treatment: adolescents contrasted with adults. Am J Orthod Dentofacial Orthop 1991; 100(6):523-30.

15. Robb SI, Sadowsky C, Schneider BJ, BeGole EA. Effectiveness and duration of orthodontic treatment in adults and adolescents. Am J Orthod Dentofacial Orthop 1998; 114(4):383-6.

16. Proffit WR. Early stages of development. In: Proffit WR, with Fields HW, Jr, et al., editors. Contemporary orthodontics. 3rd edition. St. Louis, Missouri : Mosby, Inc., 2000: 91.

Chapter Five

Appendix

5.1 Ethics Approval

Health Research Ethics Board | biomedical research | health research

2J2.27 Walter Mackenzie Centre
University of Alberta, Edmonton, Alberta T6C 2R7
p.780.492.9724 f.780.492.7303
ethics@med.ualberta.ca

3-48 Corbett Hall, University of Alberta
Edmonton, Alberta T6C 2C4
p.780.492.0839 f.780.492.1626
ethics@www.rehabmed.ualberta.ca

UNIVERSITY OF ALBERTA HEALTH SCIENCES FACULTIES,
CAPITAL HEALTH AUTHORITY, AND CARITAS HEALTH GROUP

HEALTH RESEARCH ETHICS APPROVAL

Date:	October 2002
Name of Applicant:	Dr. Kurt Popowich & Dr Paul Major
Organization:	University of Alberta
Department:	Dentistry
Project Title:	Investigation of treatment variables that affect the duration of Class II treatment

The Health Research Ethics Board (HREB) has reviewed the protocol for this project and found it to be acceptable within the limitations of human experimentation. The HREB has also reviewed and approved the subject information letter and consent form.

The deliberations of the HREB included all elements described in Section 50 of the *Health Information Act*, and found the study to be in compliance with all the applicable requirements of the Act. The HREB determined that obtaining consent for the disclosure of the health information to be used in the research from the individuals who are the subjects of the information would not be reasonable, feasible, or practical given the retrospective nature of the study.

The approval for the study as presented is valid for one year. It may be extended following completion of the yearly report form. Any proposed changes to the study must be submitted to the Health Research Ethics Board for approval. Written notification must be sent to the HREB when the project is complete or terminated.

Sharon Warren

Dr. Sharon Warren
Chair of the Health Research Ethics Board (B: Health Research)

File number: B-160602-DENT

University of Alberta | Capital Health | CARITAS HEALTH GROUP

5.2 PAR Index Score Sheet

Model No. _____

PRE TX PAR		**POST TX PAR**	
Component	**Score**	**Component**	**Score**
OCCLUSAL FEATURES		**OCCLUSAL FEATURES**	
Maxillary		**Maxillary**	
Right _____	_____	Right _____	_____
Anterior _____	_____	Anterior _____	_____
Left _____	_____	Left _____	_____
Mandibular		**Mandibular**	
Right _____	_____	Right _____	_____
Anterior _____	_____	**Anterior** _____	_____
Left _____	_____	Left _____	_____
BUCCAL OCCLUSION		**BUCCAL OCCLUSION**	
Rt	**Lt**	**Rt**	**Lt**
A-P _____	_____	**A-P** _____	_____
Vertical _____	_____	Vertical _____	_____
Transv. _____	_____	Transv. _____	_____
OVERJET		**OVERJET**	
Overjet	_____	Overjet	_____
Anterior crossbites	_____	Anterior crossbites	_____
OVERBITE		**OVERBITE**	
Openbite	_____	Openbite	_____
Overbite	_____	Overbite	_____
CENTERLINE	_____	**CENTERLINE**	_____
TOTAL	_____	**TOTAL**	_____

PRE-TX MODEL MEASUREMENTS

Overjet = _____ Overbite = _____